A FLORISTIC ASSESSMENT OF THE TURFLOOP NATURE RESERVE

By

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DECLARATION

I declare that this Dissertation hereby submitted to the University of Limpopo for the degree of Master of Science, is my own work and has not been previously submitted by me for a degree at another institution. I furthermore cede copyright of the dissertation in favour of the University of Limpopo (Turfloop).

Mashatole Masilo Makome

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Signature Date

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ABSTRACT

The aim of the study was to generate new ecological data for the Turfloop Nature Reserve (TNR), which would lead to practical management recommendations that should reduce or minimise the current negative anthropogenic and ecological impacts on the TNR.

A limited ethnobotanical survey was conducted at the two villages, Badimong and Ga-kama, surrounding the TNR. Questionnaires were used to ascertain these communities' attitude towards the reserve and their use of the reserve. Results show that the surrounding communities have great interest in the reserve for various socio-economic reasons. These include collecting wood for building, firewood and grass for thatching, resulting in serious damage to the reserve. Utilisation of the reserve is motivated by high levels of poverty, and a general absence of environmental knowledge.

A phytosociological study of the vegetation was undertaken using the Braun-Blanquet method. A total of 33 plots were sampled and classified by means of TURBOVEG, TWINSPAN and MEGATAB. The study revealed that the vegetation of the TNR could be divided into five main communities, some with a number of sub-communities and variants. The TNR is composed of two different vegetation types, namely the Mamabolo Mountain Bushveld and Polokwane Plateau Bushveld.

Recommendations on viable ecological vegetation management, to minimize current anthropogenic influences on the reserve, are provided.

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LIST OF ABBREVIATIONS

ABET – Adult Basic Education and Training

CBD – Central Business District

CBNRM – Community-based Natural Resource Management

CPRC – Chronic Poverty Research Centre

DEAT – Department of Environmental Affairs and Tourism

DWAF – Department of Water Affairs and Forestry

ECA – Environmental Conservation Act

DEDET – Department of Economic Development, Environment and Tourism

DFED – Department of Finance and Economic Development

DCA – Detrended Correspondence Analysis

GDP – Gross Domestic Product

HDI – Human Development Index

INR – Introduction to International Relations

ISO – International Organization for Standardization

ISRDS – Integrated Sustainable Rural Development Strategy

LEDET– Limpopo Department of Economic Development, Environment and Tourism

LEMA – Limpopo Environmental Management Act

LTPB – Limpopo Tourism and Parks Board

MMB – Mamabolo Mountain Bushveld

NEMA – National Environmental Management Act

NEMBA – National Environmental Management Biodiversity Act

NGO – Non – Government Organization

NRF – National Research Foundation

PPB – Polokwane Plateau Bushveld

SD – Standard Deviation

SANBI – South African National Biodiversity Institute

SMMEs – Small, Medium and Macro Enterprises

TNR – Turfloop Nature Reserve

UNCCD – United Nation Convention to Combat Desertification

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

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 (DEAT, 2004).

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 (DEAT, 2004). Alien organisms can replace large numbers (even whole populations) of native species, and use greater quantities of scarce water resources than indigenous vegetation (DEAT, 2004).

Rapid population growth and inappropriate government policies encouraged cultivation in unsuitable areas, and the use of poor agricultural methods to produce food has further exacerbated the situation (DEAT, 1997). Recent policies, international conventions, research and community-based initiatives are aiming to improve conservation and promote a more sustainable use of natural resources (Barnard and Newby, 1999).

Ecological data can indicate medium to long-term changes in the environment via its vegetation. High-quality data on environmental change depends on accuracy of the gathered information, which itself depends upon the frequency of observations, and secondly on the availability of data on environmental events (e.g. fires, floods and anthropogenic influences). The availability of data on species occurrences over time provides us with the ability to analyse and interpret environmental change. Obviously, a special type of information is needed, namely knowledge about the species and communities demands on the environment, or what they indicate (Radim, 2005).

2. CONSERVATION

2.1 Biodiversity conservation

The term conservation has in the past been broadly used to include protection, use, maintenance, restoration and enhancement of the natural environment. However, the International Convention on Biological Diversity uses the term conservation in a different way. It refers both to the "conservation of biological diversity", and the "sustainable use of its components". The aims of biodiversity conservation in SA are to maintain and strengthen existing arrangements to conserve South Africa's indigenous biodiversity, both inside and outside of protected areas (DEAT, 2006).

2.1.1 Policy and Strategy

South Africa has a substantial body of law to conserve biodiversity, especially within protected areas and for several plant and vertebrate species. However, past approaches to biodiversity conservation have not given adequate attention to the conservation of landscapes and ecosystems outside protected areas, and have neglected to consider lesser known groups such as invertebrates, fungi and micro-organisms (DEAT, 2003).

Through biodiversity conservation policy and the introduction of appropriate measures, government intends to adopt a more holistic and coordinated approach towards the conservation of biodiversity. To achieve the objective, government, in collaboration with interested and affected parties, will (DEAT, 1996):

a) Conserve components of biodiversity identified through a variety of mechanisms such as legislation, planning controls, guidelines, and protected area designations, giving priority to components of biodiversity that require urgent protective measures.
b) Consolidate, coordinate and improve existing legislation and regulations where ever possible and appropriate in order to eliminate duplication, and to avoid conflicting interpretations and implementation.
c) Introduce legal measures and incentives to conserve important ecosystems, habitats, and landscapes outside of protected areas,

including rangelands and their associated vegetation and indigenous wildlife resources.

d) Promote an ecological management approach to planning, whereby conservation is proactively incorporated into land use plans.
e) Facilitate the development of appropriate legislation to achieve uniform legal coverage for the protection of threatened species and the regulation of trade of all CITES-listed species, in addition to threatened species listed nationally and provincially.
f) Strengthen existing support for research on the improved understanding of the structure, function and composition of South Africa's terrestrial, aquatic, and marine and coastal ecosystems.
g) Improve knowledge of and take appropriate action to conserve poorly known groups such as invertebrates, fungi and micro-organisms.
h) Promote and support measures to manage conflict arising from the conservation and use of biological resources.

2.2 Terrestrial Protected Areas

South Africa's system of terrestrial protected areas is well developed, and it is in such areas that biodiversity conservation has been focused. The 422 formally protected areas in South Africa constitute some 6% of the land surface area. In these areas about 74% of plant, 92% of amphibian and reptile, 97% of bird, and 93% of mammal species are estimated to be represented. However, this does not imply the adequate conservation of genetic diversity within these areas. Furthermore, many of the existing protected areas are small, often isolated from one another, and separated by large areas of transformed land. Aggravating this situation is the fact that protected areas have been managed as islands of biodiversity rather than as part of a holistic land-use policy. Of concern is the fact that the existing system has arisen through a largely *ad hoc* process, rather than being part of a deliberate conservation strategy (DEAT, 1997).

2.3 Natural and conserved areas in the Limpopo Province

A total of 73.18% land cover in the Limpopo Province can still be termed natural areas (DEDET, 2006). These natural areas are divided into five

different types, namely forest and woodland, shrubland, thicket, bushland, and unaltered grassland. Thicket and bushland cover most of the remaining natural area in the province (38.91%), followed by woodland (32.71%). The remaining vegetation types consist of small areas; grasslands cover just over 1.0%, forest 0.31% and shrubland 0.02% of the total area (Limpopo DFED, 2004).

Conserved areas are important in providing protection against habitat loss for biodiversity and ecological systems. Despite having an intrinsic value, terrestrial ecosystems are important for the continued well-being of all inhabitants in the Limpopo Province, in particular for rural populations, which require more natural resources to survive. In light of this, it is essential to ensure that terrestrial ecosystems are assessed, continuously monitored and management plans put in place to prevent adverse effects (Limpopo DFED, 2004).

3. MOTIVATION OF STUDY

No recent floristic information, other than the poorly documented data from 1992, at the Turfloop Nature Reserve (TNR) is available. This has resulted in an absence of appropriate environmental and ecological management plans at the TNR, which have contributed to the decline in the condition of the vegetation. This, in turn, possibly has had a detrimental effect on the animal population on the reserve.

4. RESEARCH ASSUMPTION

- Years of mismanagement, and high levels of poverty in the surrounding communities, have led to a deterioration and substantial change in the vegetation of the TNR.
- New ecological data can be generated for the TNR leading to practical management recommendations.

5. IMPLICATIONS OF THE RESEARCH PROJECT

1. The study will update floristic information on the TNR which will assist with recommendations on management strategies specifically tailored to the TNR.
2. Some of the recommendations might also be applicable to other small reserves and parks in the Province.

6. AIM AND OBJECTIVES

6.1 Aim

This study aims to generate new ecological data for the TNR which would lead to practical management recommendations that should reduce or minimise negative anthropogenic and ecological impacts.

6.2 Objectives

1. Identify anthropogenic influences, by means of a semi-structured questionnaire.
2. Undertake a complete Floristic survey which would include:
    - Compiling a phytosociological table of the plant communities.
    - Identifying invasive plant species.

CHAPTER 2

LITERATURE REVIEW

1 SOCIO-ECONOMIC THREATS TO NATURAL VEGETATION

1.1 Introduction

Humans are largely dependent on terrestrial ecosystems for sustenance, raw materials and living space. South Africa is no different, and is heavily dependent on its terrestrial resources to sustain its population and to contribute to the country's economic growth (Arendse and Wilkinson, 2002).

Decades of economic development and inequitable land development policies have shaped land use patterns and consequent pressures on the natural environment (Figure 1). As a result of past policies, people were forced into subsistence lifestyles. Many of these people still dependent on natural resources to meet their nutritional, medicinal, housing and energy needs (DEAT, 1997).

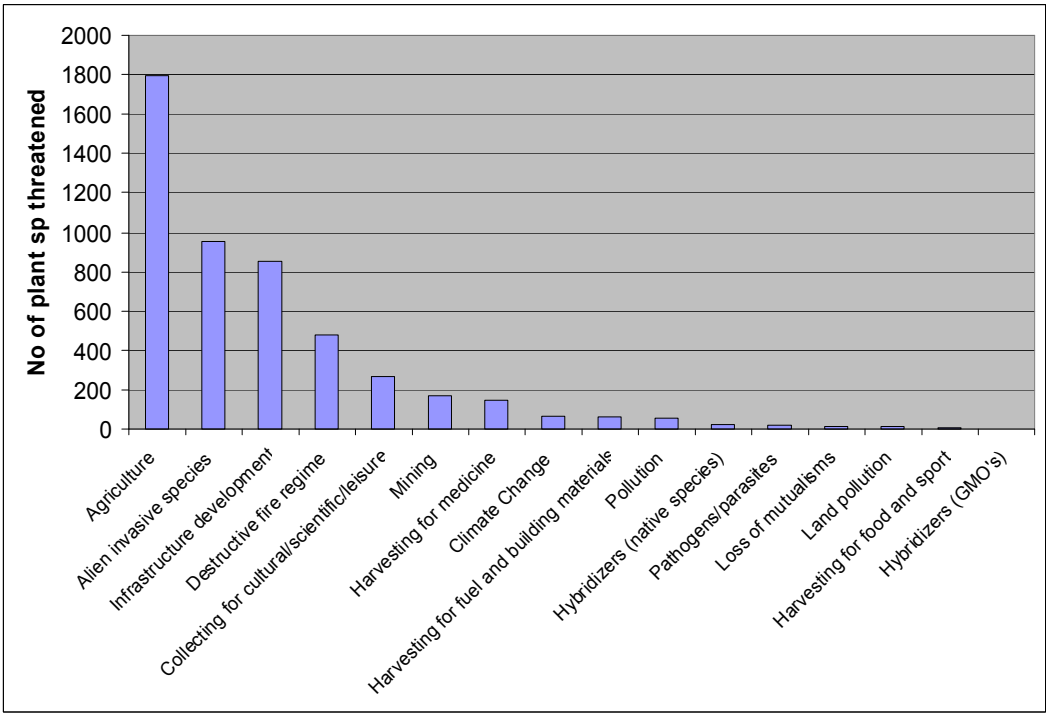

Figure 1. Socio-economic threats to the natural vegetation of South Africa (DEAT, 1997).

1.2 Unemployment

While many factors may contribute to poverty, Aliber (2003) contended that unemployment is of overriding importance as a major cause in South Africa. It has been argued that while measures such as public work programmes, anti-poverty support programmes and social safety-net arrangements may assist the poor, especially the chronically poor, these cannot replace the need for an expanding labour market and job creation (Aliber, 2003; Landman *et al.*, 2003). Natrass (2004) stated that the current unemployment situation in South Africa is "a socio-economic crisis of major proportions."

Unemployment levels in South Africa are amongst the highest in the world (Kingdon and Knight, 2001). In 1998, unemployment was officially measured at 39% on the broad definition and 26% on the narrow definition across the entire economically active population (Statistics SA, 2000). By 2003, these figures had increased to 42% and 31%, respectively (Gelb, 2003).

Recent data (Natrass, 2004) showed that some 4.7 million people are unemployed. As the largest proportion of the unemployed (52% - Gelb, 2003) fall into the poorest categories of society, the lack of unemployment opportunity is resulting in rising levels of poverty (Aliber, 2003; CPRC, 2004; Meth and Dias, 2004).

1.3 Poverty

Although South Africa is ranked as a middle-income country, the majority of households in South Africa, especially those in rural areas, live in abject poverty. Socio-economic inequality in South Africa is one of the highest in the world (Gini coefficient score = 0.6), with the gap between the rich and the poor continues to widen (Hunter *et al.*, 2003; Landman *et al*., 2003).

It has been shown that some 6% of South Africa's population, mainly urban and white, captures more than 40% of income (Woolard and Leibbrandt, 2001). Furthermore, the country's capita GPD of US$9 401 per annum places it as one of the 50 wealthiest nations in the world, while the poor social indicators of the country result in South Africa being ranked 107 out of 173

countries in terms of its Human Development Index (HDI) in 2001 – down on its ranking of 93 in 1992 (Hunter *et al.*, 2003). The most recent HDI value for South Africa is 0.674 which places it as 121 out of 177 countries (UNDP, 2007).

1.4 Rapid population growth

Rapid population growth, especially in developing countries, has had a serious impact on biodiversity. Destruction of species by humans will eventually lead to extinction of the human species through natural selection. 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 (DEAT, 2004).

1.5 Over exploitation of resources

International demand for resources such as timber, and for biological resources such as wild animals, certain types of plants, and products such as elephant ivory and rhino horn, cause changes to the terrestrial ecosystems. In some cases, the combination of domestic and international demand acts as a driver for the over exploitation of resources, which has caused many species to become endangered or extinct (CBD, 2001).

1.6 Influence of plantations

International pressure has also caused a shift away from harvesting of timber from natural forests to the expansion of plantation forestry, which on the one hand prevents further destruction of natural forests, and the associated loss of biodiversity; whilst on the other hand contributes to the spread of alien vegetation. This places a high demand on water resources, and contributes to the loss and fragmentation of natural habitats (DEAT, 2004).

1.7 Overgrazing

Overgrazing occurs when plants are exposed to grazing for too long, or without sufficient recovery periods. It reduces the use of the land and is one

cause of desertification and erosion. Overgrazing lead to the uncontrolled spread of non-native plants (Chilcott *et al*., 2003).

Mismanaging grazing land by overstocking can further lead to bush encroachment, drying up of springs and low animal productivity (Doran *et al*., 1979). Environmental effects of overgrazing contribute to contamination of ground water, eutrophication and compaction of soil. Overgrazing is not alone in contributing to soil erosion. The most important human causes are inappropriate land use policies, population pressure, rural poverty, insufficient ecological knowledge and inappropriate technology. Farmland left fallow for longer and then stocked with cattle and goats results in soil with a very low infiltration capacity of rainwater (Sandstrom, 1995).

1.8 Threats of soil composition and structure destruction

Despite evidence that there is considerable acidification and nutrient depletion in South African soils, the most challenging feature is the capacity of the soil to absorb rainwater, to erode less and to offer more water to the plant. At the risk of overstating the obvious, soil quality and soil structure (especially surface structure) are, in a rain-starved landscape, almost synonymous. Structural stability depends on burning and runoff, including electrolyte concentration, affected by the qualities of soil and vegetation. At the surface, soil aggregates are exposed to the force of raindrops, clay disperses, pores become blocked, and runoff, soil loss and soil aridity are intensified (Mills and Fey, 2003).

1.9 Spread of alien species

Invasive alien species are plants that are introduced into South Africa from other countries for economic or ecological purposes. Some, brought in unintentionally, without their natural enemies, are able to reproduce and spread prolifically. The plants or seeds enter the country in a number of different ways: for example on people’s shoes, tents, by mail order on ships, planes etc. Even animals that cross borders can carry the seeds into the country. The invader plants and seeds spread rapidly and compete for the growing space of indigenous plants. Invasive alien plants threaten the

indigenous vegetation as they use valuable and limited water resources. Many invasive plants are also responsible for hot fires and affect the makeup of the soil structure (Wynberg, 2002).

1.10 Vegetation change

The vegetation in any given area is dynamic and changes continually 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 effect 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 variable 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, 1999).

Human influences are also arresting factors, which usually lead to secondary succession. These can include deforestation, which leads to the removal of the plants from the ecosystem that can lead to soil erosion (ECHEAT, 2004). Pollution caused by humans can affect vegetation on three different scales, namely globally, nationally and locally. An example of national pollution which affects vegetation change is acid rain which kills plants and can change the balance of nutrients in the soil favouring certain types of plants. An example of

pollution on a global scale is global warming, 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).

2 COMPONENTS OF A MANAGEMENT PLAN

2.1 Introduction

Management systems provide order, consistency and continuity for to address ecological and environmental concerns through the allocation of resources, assignment of responsibilities, and ongoing evaluation of practices, procedure and processes. Such an integrated approach helps protect human health and the environment from the potential impacts of the human activities, products or services, and assist in maintaining and improving the quality of the environment (Envirodel, 2004).

A management system also intends to establish transparency and accountability in terms of the responsibility accepted towards the sustainable management and development of its priceless assets. New developments, contracts and contractors, management activities, products, services etc. can continuously be incorporated. The management system is therefore adaptable to changes, being it environmental changes or any other. An environmental management system is that part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy, objective and goals (ISO14000, 1998).

This management plan is therefore in the format of management procedures and technical procedures that specifically address the why, what, how, by whom and by when. These procedures should be of such a format that is easy to understand, implement, review, adapt and it should spell out how

ecological management and monitoring should be conducted (Envirodel, 2004).

2.2 Management plan

According to Bothma (1998), a management plan is the product of a management process. In broad outline it consists of the following series of steps, many of which can be carried out simultaneously:

- A comprehensive description of the ecosystem.
- Determination of available manpower, expertise and finances.
- Determination of land- use patterns.
- A definition of the permissible limits of any changes.
- Prediction of future trends and needs of the area and its users.
- The compilation of a time schedule for the management plan.
- A description of all realistic options which may help to achieve the management objectives; especially with regard to manpower, finances and the available expertise.

Goals and Objectives (Bothma, 1998).

- Provide order, consistency and continuity for Nature Reserves to address ecological and environmental aspects.
- Produce a framework for the allocation of resources.
- Assign roles, responsibilities and time frames.
- Provide a framework for the ongoing evaluation of practices, procedures and processes.
- Establish a framework to proof accountability towards sound environmental management.
- Provide guidance in terms of how ecological management and monitoring should be conducted.
- Provide technical information regarding ecological management and monitoring actions.
- Render scientific support to management.

2.3 Management actions

2.3.1 Game numbers and carrying capacity

When the stocking rate exceeds the carrying capacity, overgrazing/over browsing takes place. Game naturally tends to utilize certain areas more than others, causing local areas to be overgrazed and other areas under-utilised. This can happen under an overstocking regime (Schmidt, 1995). Many management programs and actions are therefore aimed to prevent selective overgrazing and overbrowsing (Bothma, 2002). The placement of water points and management thereof can be used effectively to alleviate grazing pressure, as well as to increase utilization of previously under-utilized areas (Envirodel, 2004).

2.3.2 Bush control

According to Bothma (2002), bush control as a management tool works fundamentally in two ways:

A. Thinning out reduces competition for grass layer and therefore improves veld condition (increase of palatable grasses = higher quality grazing), which makes the thinned areas more attractive to game.
B. The majority of the common game species prefers a more open savanna type woody structure. Former under-used area by thinning out the bush in that area can be easily accessed after, resulting in more even veld utilization.

2.3.3 Fire as management tool

Fire has always played a crucial role in the maintenance of savannah areas, and together with rainfall and grazing it is considered the most important and dominant driving forces maintaining the savanna ecosystem (Trollope, 1983). The most important roles of fire are (Trollope, 1984):

a) Maintaining the balance between the grass and tree layer.
b) Thinning out encroached bush.

c) Maintaining an optimal vegetative species composition.
d) Increase utilization of under utilized veld.
e) Improve quality of grazing, particularly in more ‘’ sour’’, unpalatable areas.
f) Relieve grazing pressure on preferred veld/ habitats by attracting grazers to burnt veld elsewhere.
g) Rejuvenation of the grass layer- improved grazing production.
h) Removal of moribund grass which is not utilized.

Fire can, however, cause degradation of veld, particularly if too frequent burning take place, or if veld has been allowed to build up excessive fuel loads which results in destructively hot fires. The absence of fire is also detrimental – large areas of the savannas of southern Africa suffer serious bush encroachment largely due to the absence of fire, or infrequent burning regimes (Tainton 1999). In sour veld areas fire serves to improve the quality of veld through the removal of old, coarse grass material, as well as the promotion of more palatable grass species, and the reduction of the amount of unpalatable grass species in the veld (Luke and McArthur, 1978).

Fire kills off many seedlings and young trees, and even larger tress as well, thereby preventing encroachment, and opening the woody layer, on condition that the fuel load is sufficient. Game has a definite preference for recently burnt veld, due to increased palatability of the young, fresh grass that grows out after fire. It is therefore very important that stocking rates are within the carrying capacity and that fairly large areas are burned. It is for this reason that grazing by domestic animals is not permissible on burned areas within 14 days after a burn (Trollope, 1984).

Tainton (1999) stated that apart from controlling woody plants, fire improves the quality and palatability of grazing. It can therefore be used to increase utilization of previously under utilized areas, whereby overgrazing of other areas can be alleviated.

3 LEGISLATION

3.1 National Environmental Management Biodiversity Act (NEMBA)

The objectives of the National Environmental Management Biodiversity Act are to provide for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act, 1998; the protection of species and ecosystems that warrant national protection; the sustainable use of indigenous biological resources and equitable sharing benefits arising from bio prospecting involving indigenous biological resources; the establishment and functions of South African National Biodiversity Institute; and for matters connected therewith (DEAT, 2004).

3.2 National Environmental Management Act (NEMA)

The objectives are to provide for co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environment functions exercised by organs of state; and to provide for matters connected therewith (DEAT, 1998).

3.3 Environment Conservation Act (ECA)

The objectives of the Environment Conservation Act are to provide for the effective protection and controlled utilization of the environment and for matters incidental thereto (DEAT, 1989).

The Act is to be applied with a view to:

a) The protection of ecological processes, natural systems and the natural beauty as well as the preservation of biotic diversity in the natural environment.
b) The promotion of sustainable utilization of species and ecosystems and the effective application and re-use of natural resources.
c) The protection of the environment against disturbance, deterioration, defacement, poisoning, pollution or destruction as a result of man-

made structures, installations, processes or products or human activities.

d) The establishment and maintenance of acceptable human living environments in accordance with the environmental values and environmental needs of communities.

e) The promotion of the effective management of cultural resources to ensure its protection and responsible use.

f) The promotion of environmental education in order to establish an environmentally literate community with a sustainable way of life.

g) The execution and coordination of integrated environmental monitoring programmes.

3.4 Limpopo Environmental Management Act (LEMA)

The objectives of the Limpopo Environmental Management Act are to: manage and protect the environment in the Province, to secure ecologically sustainable development and contribute to the progressive realization of the fundamental rights contained in Section 24 of the Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996), and to give effect to international agreements effecting environmental management which are binding on the Province. Limpopo Province interprets and applies the Environmental Management Act in accordance with the National Environmental Management Act principles, thereby adhering to the principles of cooperative governance.

The chapters of the Environmental Management Act has provisions for the management of Environmental Advisory Bodies, Protected Areas, Wild and alien animals, Professional hunting, Aquatic biota and aquatic systems, Invertebrates, Indigenous plants, CITES, Preservation of caves and cave formation, Limited development areas, Mountain catchments areas, Environmental pollution, Environmental compliance officers, Permits, Permissions, Exemptions and exclusions and Offences, Evidence, Penalties and forfeitures (Rampedi and Moshibudi, 2004).

4 FINDINGS FROM PAST STUDIES

Findings from past studies are important in understanding the current state of the reserve. They also provide us with information on successional stages that occurred on the reserve. Research by Bredenkamp and Van Vuuren (1977) covered a floristic assessment. Work done by the Limpopo DFED (1992) relates to the identification of plant species, management of the veld, and control of alien and exotic plant species. In 2006, Mashatole undertaken a pilot ecological survey of the reserve to update the findings of Bredenkamp and Van Vuuren (1977).

4.1 Bredenkamp and Van Vuuren (1977)

The vegetation of the Turfloop Nature Reserve was classified by means of the Braun-Blanquet method. Differences in vegetation were associated with differences in topography and various soil properties. The following five plant communities were identified (Figure 2):

1. Pioneer *Scirpus triqueter* Wetland community in the permanent streams directly below the dam wall.
2. *Phragmitis australis* Reed community in the seasonally flooded wetland below the dam wall.
3. *Acacia Karoo* Riverine communities:
   (a) *Acacia karroo* - *Ziziphus mucronata* Thickets along the stream banks.
   (b) *Acacia karroo* - *Sporobolus africanus* Savanna on the clay soil adjacent to the stream banks.
4. *Acacia tortilis* Savanna communities of the undulating drier areas surrounding the wetland.
   (a) *Acacia tortilis* - *Spirostachys africana* Savanna of the south facing slopes.
   (b) *Acacia tortilis* - *Euclea crispa* Savanna of the north-east facing slopes.
   (c) *Acacia tortilis* - *Pogonarthria squarrosa* Savanna of the north facing slopes.
5. *Cynodon dactylon* Grasssveld community of the flat plains.

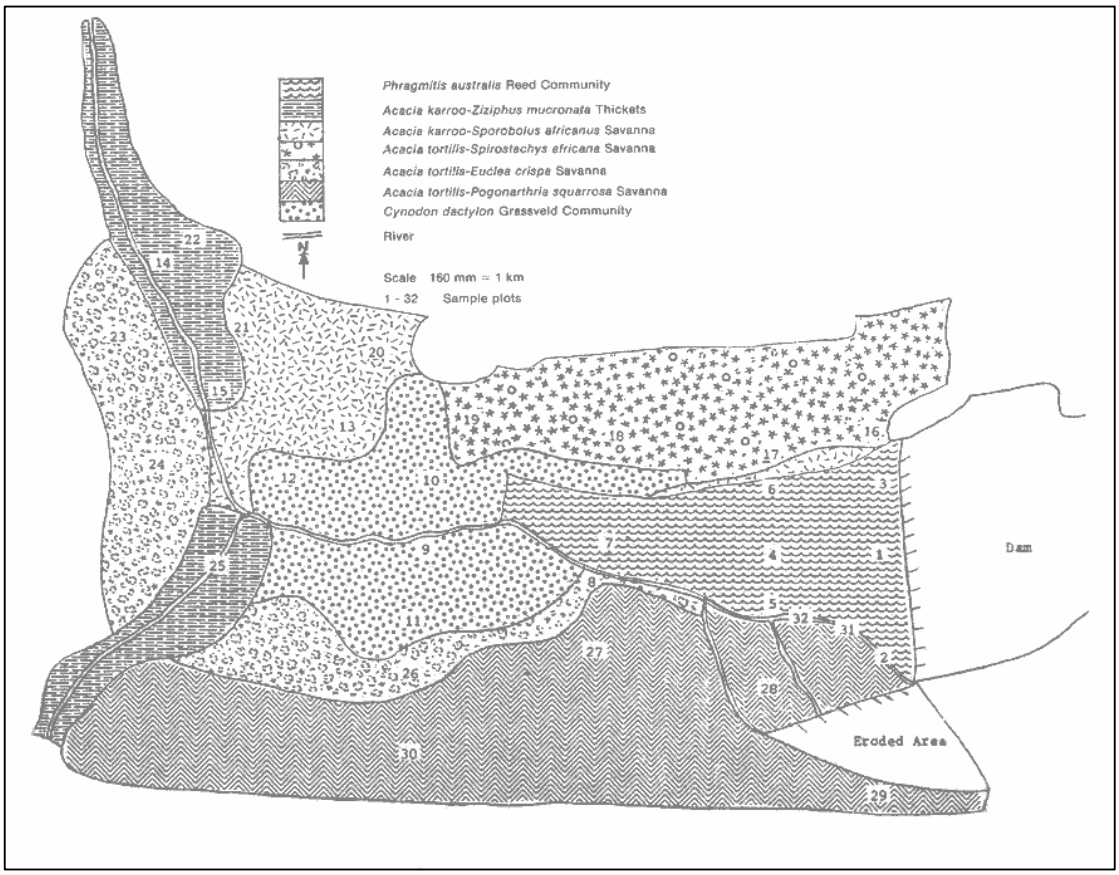

Figure 2. Plants communities as classified by Bredenkamp and Van Vuuren (1977).

According to Bredenkamp and Van Vuuren (1977), the most conspicuous feature of the study area was the poor vegetation condition of the veld. This condition was due to mismanagement and misuse, especially overgrazing and trampling by cattle and goats of the local population. Bredenkamp and Van Vuuren (1977) concluded that the vegetation, especially the herbaceous layer, would change under better management regimes. These changes would probably not affect the classification, but the floristic composition and the relative abundance of the different species present in the herbaceous layer would probably change.

4.2 Limpopo DFED (1992)

Not much information can be gleaned from the records obtained from Limpopo DFED (1992). What is evident is that the Limpopo DFED (1992) had not done a vegetation survey on the reserve since it came into their

possession. As such no comparisons can be drawn between their work and that of Bredenkamp and Van Vuuren (1977). However, reserve management carried out a lot of eradication of exotic vegetation and introduced appropriate control measures on the reserve. In this regard, plants such as Prickly pear (*Opuntia ficus-indica*), Sickle bush (*Dichrostachys cinerea*), wild tobacco (*Nicotiana glocua*), poplars (*Populus x canescens*), blue gums (*Eucalyptus grandis*) and large-leaved Fluff-bush (*Lopholaena crocidura*) were continuously being controlled by mechanical and chemical measures. No serious bush encroachment was noted on the reserve. From the 1992 records it is evident that the illegal entering of the surrounding locals was already a serious problem which led to the destruction of some of the large *Acacia* trees for firewood. No records dated after 1992 were available from the Limpopo DFED (1992).

4.3 Mashatole (2006)

A preliminary survey of the TNR was undertaken in 2006 (Mashatole, 2006). Notable differences were found in comparison with the data of Bredenkamp and Van Vuuren (1977) and Limpopo DFED (1992). These included:

- The condition of the grass and herb stratum increased, probably due to the current limits of cattles on the reserve.
- There were significant changes in the grass species composition between the surveys. At least 35 plant species that were recorded in the 1977 survey were absent from the 2006 survey. In contrast 34 new species were recorded in 2006, which were not present in Bredenkamp and Van Vuuren's 1977 survey.
- The number of exotic species increased, indicating a general degradation of the veld in the last 30 years.
- The woody stratum, composed mostly of *Acacia karroo*, has now decreased to a low stratum; possibly due to the continued harvesting of wood by locals for firewood and building materials.
- The preliminary survey indicated that the reserve was continuing to experience the negative impacts via anthropogenic and/or ecological acts which was recorded by the 1977 survey and documented in the

1992 report. These negative impacts have led to the extinction of dominating species such as *Sclerocarya birrea* from the reserve.

CHAPTER 3

DESCRIPTION OF STUDY AREA

1. TURFLOOP NATURE RESERVE

1.1 Location

The TNR is located 35 km east of Polokwane in the Limpopo Province along the R71 road (Figure 3). The TNR is bordered by the University of Limpopo (Turfloop Campus) on the west, the R71 road (linking Polokwane and Tzaneen) and Badimong village on the south, Ga-Kama village on its north (Figure 4) and communal land on the east.

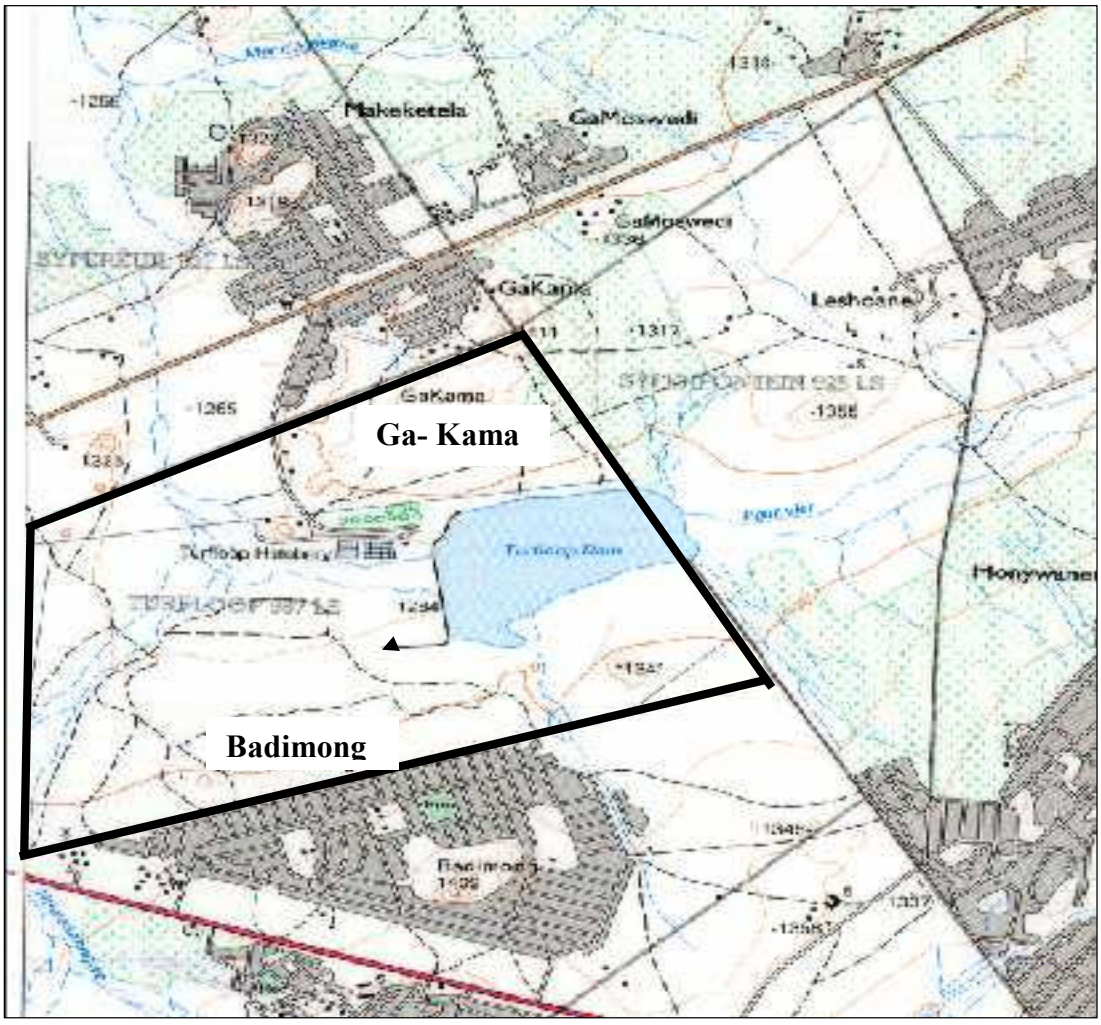

Figure 3. Map (1:150 000) indicating the location of the TNR (blocked area).

Figure 4. The TNR in the foreground and Ga-Kama village in the background.

1.2 Size

The reserve is 550 ha in size, which includes an estimated 50 ha of granite hills, agricultural facilities, and a dam (Figure 5), which is fed by the Pou River, a seasonal spruit. The Turfloop Dam is not a registered dam of the Department of Water Affairs and Forestry (DWAF), but falls under the jurisdiction of the Department of Economic Development, Environment and and Tourism (DEAT).

Figure 5. Rocky outcrop situated in the middle of the Turfloop Dam.

1.3 History

Official information on the reserve is limited. According to the Limpopo Department Nature Conservation, the reserve was placed under administration of the Lebowa Government in 1986. The management of the reserve was transferred to the Northern Province, now the Limpopo Province, in 1998. In 2001, the management of the reserve resided with the Limpopo Department of Tourism and Parks Board (DWAF, 2001). Currently, management resides with the Limpopo Economic Development, Environment and Tourism (LEDET), under an agreement entered into by LEDET and the surrounding communities, in December 2007.

1.4 Meteorology

The reserve is situated 1312 m above sea level with a mean summer temperature of 27ºC and a mean winter temperature of 18 ºC (S.A. Weather Service, 2006). According to Mucina and Rutherford (2006), the daily maximum temperatures for the area are 33.2°C or higher during the summer

months and can be as high as 24°C during June and July. Summer minimum temperatures are relatively high, exceeding 13°C. Winter minimum temperatures can be cold (0.6°C). Mean monthly maximum temperatures range between 15°C and 26°C, and mean monthly minimum temperatures between 11°C and 20°C (SA Weather Service, 2006). Incidences of frost do occur, although not very often (an average of 8 days per year). The mean annual rainfall varies between 400 mm and 600 mm (with a mean of 500 mm). Mean Annual Potential Evaporation is between 2092 and 2122 mm. The Mean Annual Soil Moisture Stress (% of days when evaporative demand was more than double the soil moisture supply) range between 77 and 80% for the area (Mucina and Rutherford, 2006). Most of the rain that occurs is in the form of late afternoon thunderstorms (SA Weather Service, 2006).

Long term (1960-62, 1977-2008) mean minimum temperature trend for Polokwane (nearest station to the TNR) (Figure 6) indicate a slight but significant rise from 11.6 ºC to 12.1 ºC. A similar trend is apparent in the long term (1960-62, 1977-2008) mean maximum temperature (Figure 7), with a significant rise from 24.65 ºC to 25.5 ºC. Conversely, the annual mean long term (1960-62, 1977-2008) rainfall for Polokwane (Figure 8) shows a slight but marked decline over the last 30 years, from 550 mm per year to 478 mm per year. The long term (1960-2008) annual humidity for Polokwane (Figure 9) similarly shows a slight but noteworthy decline from 63% to 57.5%.

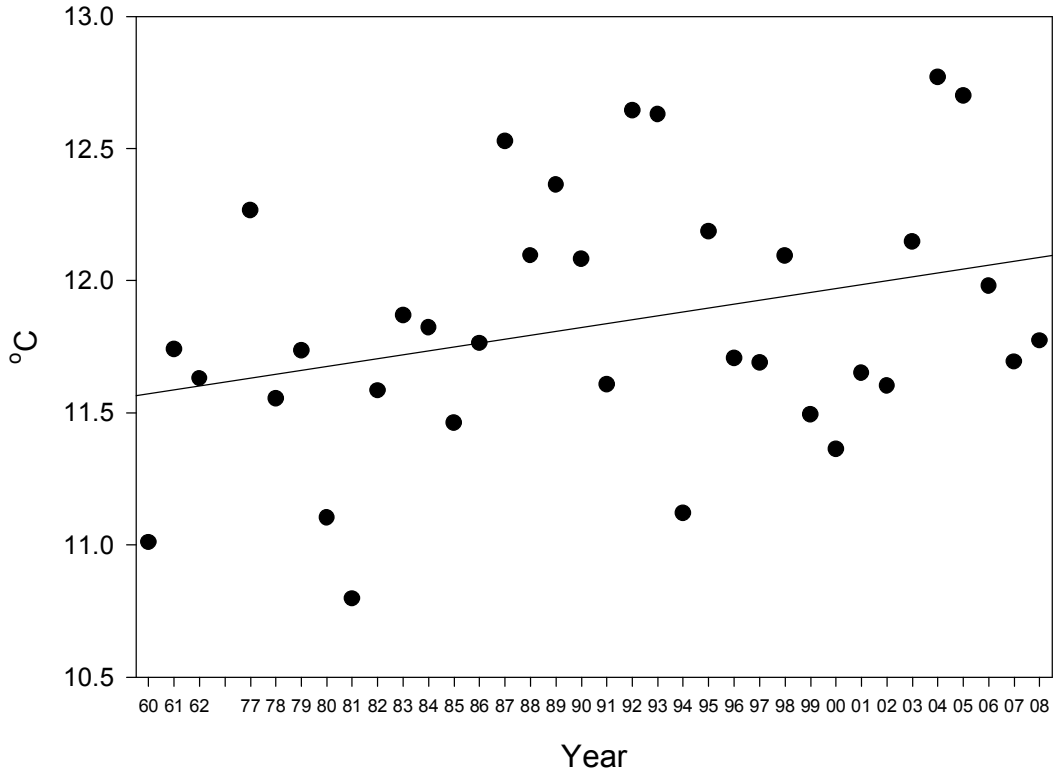

Figure 6. Long term (1960-62, 1977-2008) mean minimum temperature for Polokwane (station: 81420). Data supplied by SA Weather.

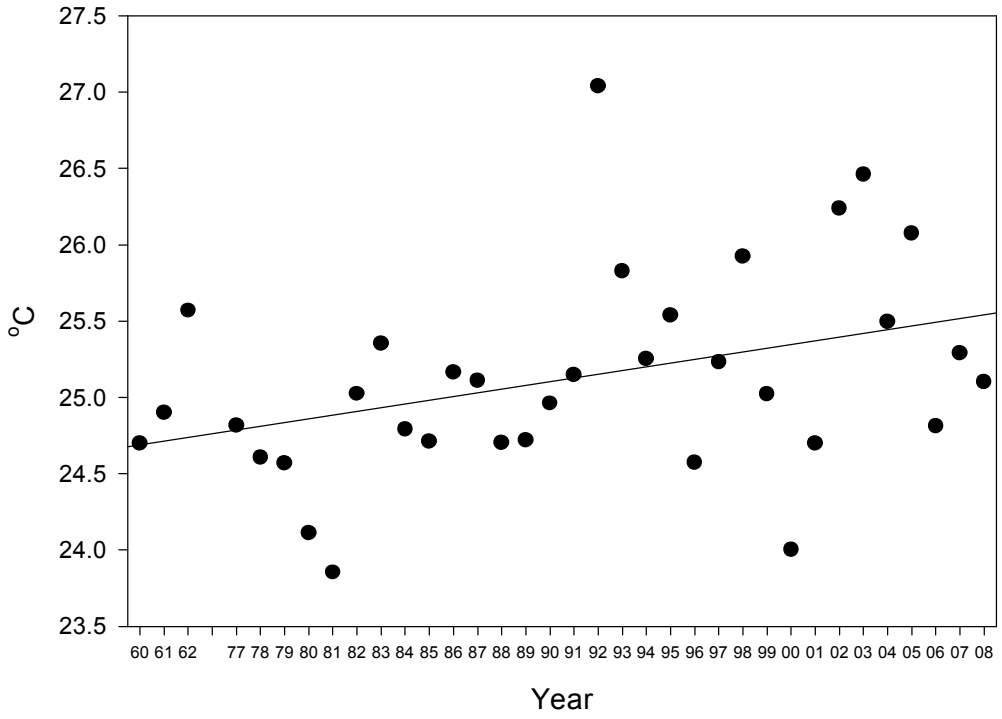

Figure 7. Long term (1960-62, 1977-2008) mean maximum temperature for Polokwane (station: 81420). Data supplied by SA Weather.

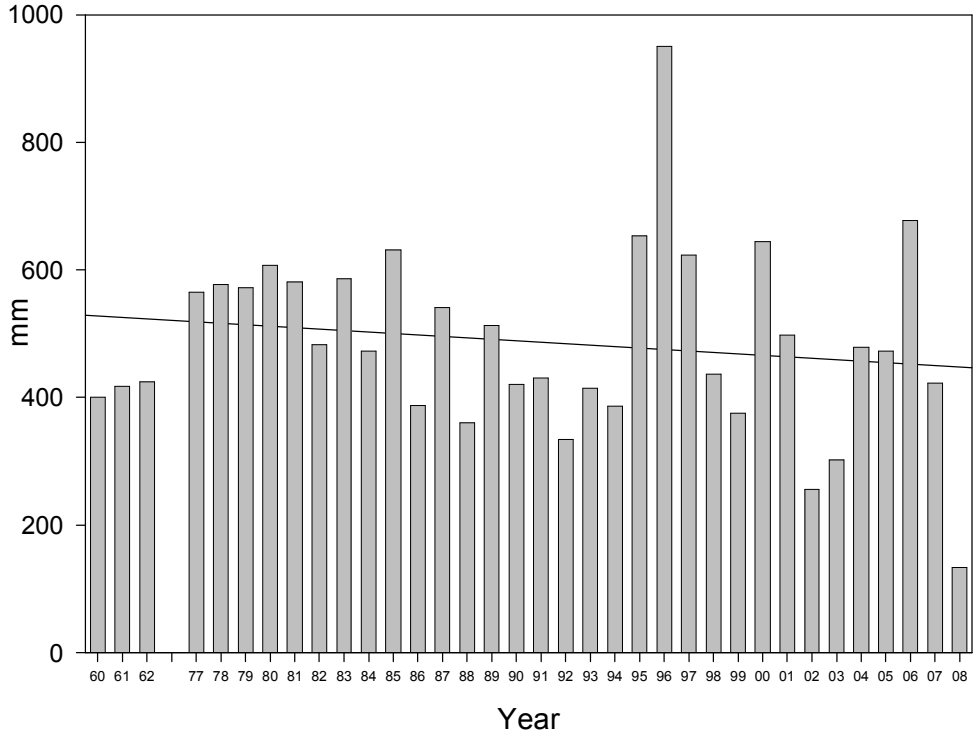

Figure 8. Long term (1960-62, 1977-2008) rainfall for Polokwane (station: 81420). Data supplied by SA Weather.

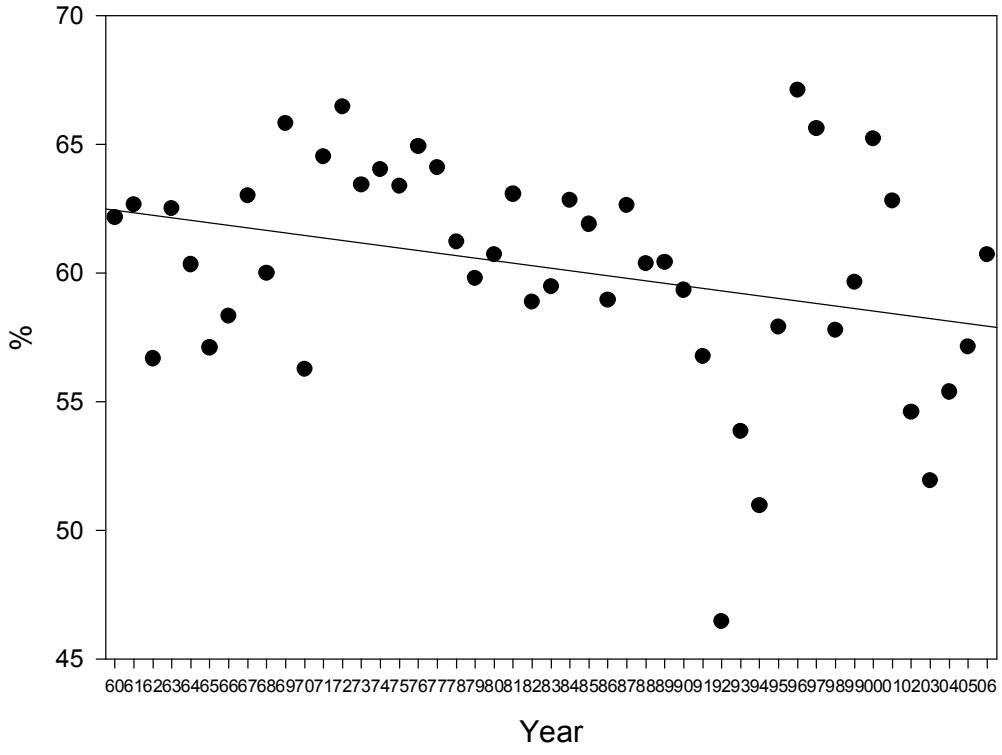

Figure 9. Long term (1960-2008) humidity for Polokwane (station: 81420). Data supplied by SA Weather.

2. DESCRIPTION OF VEGETATION TYPES

The vegetation of the area within which TNR falls, belongs to the Savanna Biome (Low and Rebelo, 1996). According to Low and Rebelo (1996), the TNR falls broadly within the Sourish Mixed Bushveld, situated on the margin of the Polokwane Plateau Bushveld (PPB) (Figure 10). The TNR is composed of elements of two overlapping vegetation types. These include the Polokwane Plateau Bushveld (PPB) and the Mamabolo Mountain Bushveld (MMB).

2.1 Polokwane Plateau Bushveld

A fine classifcation by Low and Rebelo (1996) reveales the TNR to fall within the PPB, a classification supported by Ladislav *et al*. (2005).

2.1.1 Distribution

The PPB covers the greater part of the Limpopo Province and the northern parts of the North-West Province. In the Limpopo Province it covers the higher-lying plains around Polokwane, north of the Strydpoort Mountains and south of the Makhado Sweet Bushveld. Altitude range between 1 100 and 1 500 m above sea level (Mucina and Rutherford, 2006).

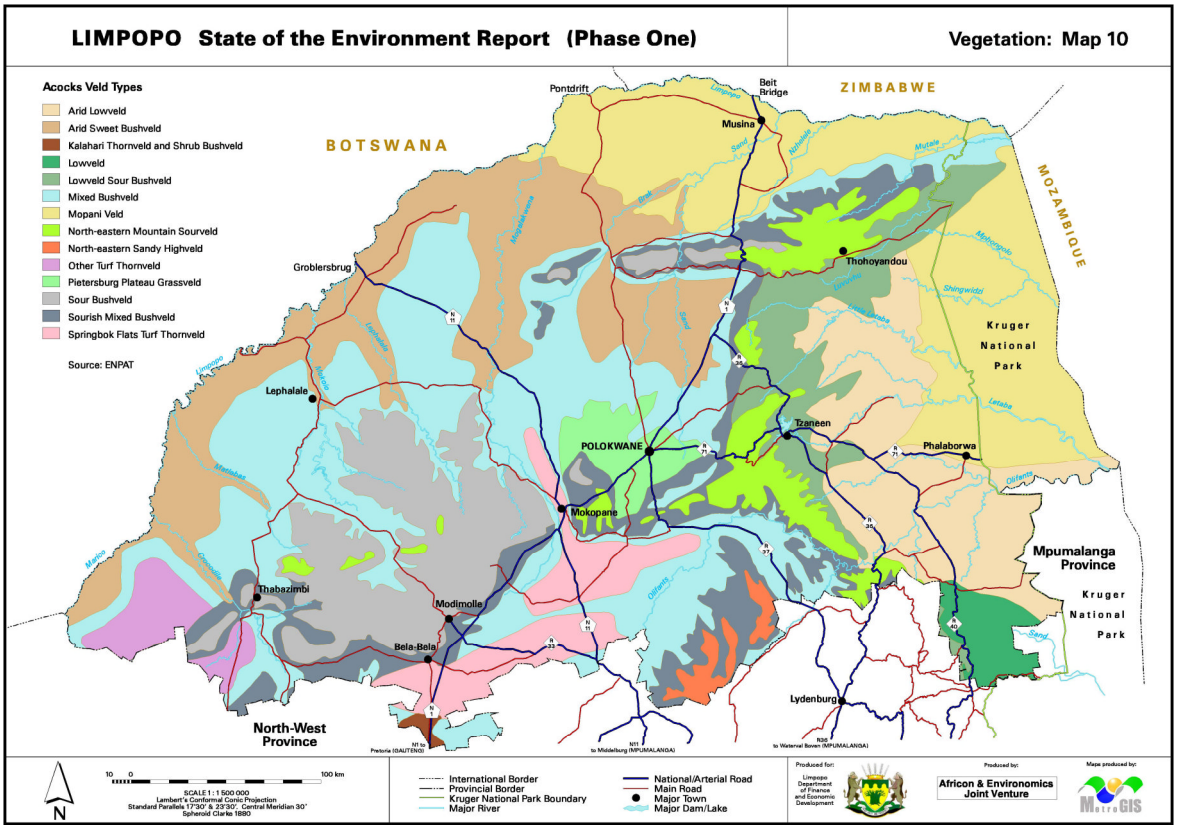

Figure 10. Map (1:150 000) indicating the Sourish Mixed Bushveld (DEDET, 2006).

2.1.2 Vegetation

This vegetation type varies from a dense, short Bushveld to an open tree savanna with a well-developed grass layer (Mucina and Rutherford, 2006).

2.1.3 General Topography

Moderately undulating plains are supplemented by a number of hills and low mountains (Mucina and Rutherford, 2006).

2.1.4 Geology

According to the South African Soil Catnaps (Soil Classification Working Group, 1977), the upper soil texture comprises loamy sand (Glenrosa), while the middle strata consist of clay loam (Oak Leaf) and the bottom stratum of sandy clay to clay (Vals Rivier) and biotite granite.

2.2 Mamabolo Mountain Bushveld

2.2.1 Distribution

The Mamabolo Mountain Bushveld (MMB) falls within Limpopo Province: East and South of the Polokwane Plateau along the foothills of the west-facing part of the eastern escarpment and of the Strydpoort and Makapan mountains. It also converges the main isolated hills and small mountains embedded within the Polokwane Plateau as far as Mogoshi Mountain in the west and De Loskop (near Mogwadi) and Renosterkoppies (around Zandrivierspoort) to the north. Altitude range between 1 200 and 1 600 m above sea level (Low and Rebelo, 1996).

2.2.2 Vegetation

Mucina and Rutherford (2006) distinguished the MMB as a subsection of the PPB. The MMB is made up of a combination of dense shrubby thickets and small trees of both *Acacia* and broad-leaved species (SANBI and DEAT, 2004). The vegetation of the MMB is distributed within the Low mountains, lower slopes of Strydpoort and Makapan ranges, and rocky hills. The slopes are moderate to steep, and very rocky, covered by small trees and shrubs. The rock slabs or domes are sparsely vegetated, and then mostly with a mixture of xerophytes, with several succulents (Low and Rebelo, 1996).

2.2.3 General Topography

Ancient granite and gneissic rocks, intrusive into the primitive systems, are exposed over a vast area. The old rocks have been worn down, and the intrusions laid bare to form the gentle undulating plains, dotted with granitic outcrops which are characteristic of the region (Du Toit, 1954).

2.2.4 Geology

The MMB has a very varied geology which includes basement granite and gneiss, clastic sediments of the Pretoria Group (Vaalian) and ultramafic and mafic metavolcanics of the Pietersburg Group (Swazian). Shallow and skeletal soil (including Mishap and Glenrosa soil forms) occur. Land types are mainly Ib and Fa (Low and Rebelo, 1996). According to Dlomu (1966), great

diurnal variations of temperature have favoured the weathering of the granite into large boulders associated with fine sandy materials. The grey ferruginous lateritic soils are shallow and spread over the old granitic rock. Colluvial soils are found around the granitic outcrops, while alluvial soils are found in the river valley.

3. FAUNA

The TNR is stocked with a number of antelopes, such as Wildebeest (Figure 11), Impala and Kudu. A number of Giraffes and Ostriches (Figure 12) are also housed on the reserve.

Figure 11. Wildebeest on the TNR.

Figure 12. Ostriches on the TNR.

CHAPTER 4

METHODOLOGY

1. ETHNOBOTANICAL SURVEY

1.1 Method

In order to determine the uses of and attitude towards the reserve by the surrounding communities and its implication on the management of the reserve, interviews were conducted via a semi-structured questionnaire (Addendum 1) with 30 randomly-selected people from each of the two surrounding villages (Ga-Kama and Badimong). Both genders were equally represented within the sample. Interviews were conducted in Northern Sotho, the native language of respondents, to aid in a better rapport between the interviewer and interviewee. This study was conducted in March 2006

1.2 Data analysis

Descriptive statistics were used to describe the collected data. Data were analysed quantitatively and presented in tables, and expressed in percentage. The percentages did not always add up to 100% due to absence of responses by some participants.

2. FLORISTIC SURVEY

The Braun-Blanquet approach to vegetation classification provides a comprehensive floristic description of each relevé (Werger, 1974). It is a widely used technique in southern Africa (Rogers, 1993). According to Whittaker (1975), the method is based upon the following principles:

1. Plant communities can be recognised from their floristic composition, which reflects the relationship between plants and their environment.
2. Certain plant species are more sensitive indicators of environmental gradients than others, and can consequently be used as diagnostic species for a given community.
3. Plant communities can be organised into hierarchical classes based upon their diagnostic species.

2.1 Stratification

Stratification was based on the five terrain units (Land Type Survey Staff, 1985), namely; 1- crest, 2- scarp, 3- midslope, 4- footslope and 5- valley bottom or floodplain. After an intensive reconnaissance of the area, the TNR was stratified into three main units, namely:

1. Hills, rocky outcrops and ridges, which included the crest and scarp.
2. Riverine areas, floodplains and dams, including the valley bottom.
3. Plains, classified as midslope and footslope.

This method of stratification ensured that all area types were covered during sampling.

2.2 Sampling Design

A total of 18 vegetation types (ecological units) were identified from the most recent aerial micrograph (1997) taken of the reserve. In addition 1: 50 000 topographical maps and 1: 10 000 orthophotos were used to delineate specific areas of uniform vegetation structure. Two sample plots were randomly laid out in each of these vegetation types, resulting in a total of 33 sample plots (Figure 13). Plot sizes varied from 100 m^2 for herbaceous vegetation to 200 m^2 for dense woody vegetation. In order to include a realistic representation of the floristic composition and vegetation in the Riverine terrain unit, the sample plots were enlarged to 400 m^2.

Sample plots were square, with the exception of rectangular plots used on the hills. The optimal plot size was calculated by compiling a species -area curve that best represented the assemblage or community. Plots of increasing size were placed on the ground in such a way that each plot encompassesed all the smaller ones. As each larger plot was placed, a list of additional species encountered was created. When a point of diminishing return was reached, beyond which increasing the plot area resulted in the addition of only a few additional species, the plot size for the relevant area was fixed. Field data was recorded on a standard Braun-Blanquet vegetation data sheet (Addendum 2).

This study was conducted from early March 2006 to June 2007. Prior to the study, officials from Department of Nature conservation and Parks were

consulted to enquire about existing management strategies employed on the TNR and other reserves. Discussions were also held with officials from Limpopo DFED to obtain information about possible recent studies that took place on the reserve.

Figure 13. Aerial micrograph showing sampled plots indicated by black dots.

Data on vegetation structure included estimations of the percentage total canopy cover and average height of the tree, shrub and herb strata. Trees were designated as woody when taller than 2 m, and as shrubs when shorter than 2 m. Canopy cover was placed in one of seven categories by visual estimation (Table 1).

Table 1: Braun-Blanquet cover classes (Mueller and Ellenberg, 1974).

Cover value	Description
5	Cover 75- 100% of total plot area
4	Cover 51-75% of total plot area
3	Cover 26-50% of total plot area
2b	Cover 12.5-25% of total plot area
2a	Cover 5-12.5% of total plot area
1	Cover less than 5% of total plot area
+	Cover less than 1% of total plot area
r	One or few individuals, rare occurrence

Relevés were compiled for each sample plot by recording all plant species. The species were then listed according to the Braun-Blanquet cover-abundance scale (Werger, 1974).

In addition, the following parameters were documented to assist the current vegetation assessment:

- Scientific names according to Germishuizen and Meyer (2003). Vernacular tree/shrub names according to Palgrave (2002) and for non-woody species Germishuizen and Clarke (2003), Van Wyk and Malan (1988) and Pooley (1998), where applicable.
- The habited of each plant species (a measure of structural diversity) and an indication of its perenniality.
- The ecological and successional status of the grass composition of each vegetation unit (according to Van Oudtshoorn, 1999).
- Red Data assessment.
- Assessment of plant species with medicinal value.
- Identification of declared weeds and invader species as promulgated under the amended regulations (Regulation 15) of the Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983).

2.3 Habitat analysis

There is a close relationship between environmental factors and the distribution of the natural plant communities (Gauch, 1982). Therefore the physical environment has to be dealt with in phytosociological studies, as it plays an important role in the ecological interpretation of the floristic data (Bezuidenhout, 1982).

2.4 Data processing and analyses of data

Data were classified with Turboveg (version 2.37) and MEGATAB (version 2.0). TURBO (VEG), which include MEGATAB, is a software package designed for the analysis of vegetation data. It consists of routines to store, select, export and analyse vegetation data, and to present results as tables and distribution maps. The releves were classified by using Two-way Indicator Species Analysis (Twinspan) (Hill, 1979), a multivariate polithetic, and divisive clusteing algorithm (Kent and Coker, 1995), in order to derive a first approximation of the possible plant communities. TWINSPAN uses Braun-Blanquet data that describes the percentage cover of plant species as recorded in relevés. The program groups similar relevés in a two-way phytosociological table (Hill, 1979). TWINSPAN further separates relevés in a dichotomised two-way division at multiple levels, depending on their similarity. Diagnostic plant species are then used to separate groups of relevés. The classification is based on the presence or absence of a species rather than on their abundance and it is therefore a qualitative rather than a quantitative (Kent and Coker, 1992), though pseudo-species provide for the semi-qualitative Braun-Blanquet type data sets.

The TWINSPAN analysis generates an organised two-way phytosociological table of the original data matrix. Relevés are sorted into columns. The effect of the layout is to concentrate entries down the diagonal of the table from top left to bottom right. Species that are scarce or do not fit easily into the overall diagonal trend placed at the bottom of the table. The values r, +, 2a, 2b, 3, 4 and 5 within the main body of the table correspond to the Braun-Blanquet cover abundance scale. From the phytosociological table, it is possible to identify diagnostic or indicator species that are important in the differentiation

of groups of relevés (plant communities, subcommunities or variations). The TWINSPAN procedure is contained in MEGATAB (Hennekens, 1996), a virtual editor for phytosociological tables.

The TWINSPAN generated phytosociological table provided the first approximation of the vegetation units of the study area from the raw Braun-Blanquet data. This approximation was then further refined by using Braun-Blanquet procedures to obtain a final classification, which was ecologically sound as possible (Behr and Bredenkamp, 1988). This refinement involved a manual shuffling of species or relevés in MEGATAB to provide a clearer definition of the vegetation units, and identification of the diagnostic plant species.

The TWINSPAN and Braun-Blanquet procedures resulted in a hierarchical classification of the vegetation. Plant communities, sub-communities and variants were recognised, and described according to standard procedures. Although the naming of different plant communities was not formal according to the International code for syntaxonomy (Barkman *et al*., 1986), the basic principles of naming was followed to facilitate later formalisation of the proposed syntaxon names.

2.5 Ordination

Ordination procedures were used in the present study to order vegetation relevés in relation to one another in terms of their similarity in plant species composition. One of the principal aims of ordination is to define vegetation gradients and associated underlying environmental gradients within a set of vegetation data (Kent and Coker, 1992). Hypothesis concerning variation in the vegetation, and between vegetation and environmental factors then emerge, and provide direction for more specific study.

A method of indirect ordination is used in this study whereby vegetation data are analysed independently of environmental data (Kent and Coker, 1992). Environmental data are introduced only after the ordination diagram has identified the major sources of variation in the vegetation data. Interpretation

of environmental relationships is carried out on two-dimensional scatter diagrams of relevés. The distances between relevés on a scatter diagram demonstrate their extent of similarity. Inspection of the diagrams enables trends in the data to be recognised. When there are clear gradients across the diagram, then the environmental gradients present may be assigned to the axes (Kent and Coker, 1992).

Ordinations were performed to illustrate floristic relationships between plant communities and to detect possible gradients in and between communities. The results were also used to confirm the order of the communities and variations in the TWINSPAN generated phytosociological tables.

Detrended Correspondence Analysis (DCA) was selected for use in this study. The DCA procedure uncorrelates axes that overcome arch and compression effects that often distort data when other ordination procedures, for example, reciprocal averaging and principal components analysis, are used (Hill and Gauch, 1980). This is achieved through detrending, in which the main axes that are presented are calculated as means of the preliminary axes.

The axes of a DCA are scaled in units of the mean standard deviation (SD) of species turnover (Gauch, 1982). A change of approximately 50% in the species composition of a relevé occurs at $\pm$ 1 SD. The axes of detrended correspondence analysis can therefore be of variable length, depending upon the turnover rate of species between relevés and the extent of variation within the data. A data set that represents many diverse vegetation units with minimal species overlap between each other would therefore have long axes.

The DECORANA software was used to conduct a DCA on the Braun-Blanquet data of the present study (Hill and Gauch, 1980). DECORANA has become one of the most widely used ordination procedures in vegetation science since 1980 when it was introduced (Kent and Coker, 1992).

2.6 Plant identification

Plant samples were collected and taxonomically identified at the Larry Leach Herbarium of the University of Limpopo. Material that could not be identified was sent to SANBI (Pretoria) for identification.

CHAPTER 5

RESULTS

1 ETHNOBOTANICAL SURVEY

1.1 Impacts on the reserve

Results from the ethnobotanical survey indicated that the majority of respondents had some kind of interaction with the reserve (Table 2). Residents of Ga-Kama indicated that although the reserve is utilised for fishing it also has aesthetic value for them. Interestingly, none of the respondents indicated that they harvest wood from the reserve, although the author has observed this taking place on numerous occasions (Figure 14).

Figure 14. Stacked wood, to be used for firewood (TNR).

1.2 Expectations from Government

Results (Table 3) indicated that respondents from both communities were unsure who the owner of the reserve are. Fifty three percent of Ga-Kama residents had some sort of expectations of the reserve and local government. A number of residents indicated that they wanted co-ownership of the reserve, whereas some were worried about the development of the reserve. In contrast to this, 13% of the

people from Badimong wanted the reserve to be utilized for agricultural purposes to eradicate poverty. Both villages recommended that more animals be added to the reserve and the strengthening of security.

1.3 Natural resources

Badimong residents were satisfied with the current “management strategies” whereas Ga-Kama residents had some concerns. More people from Badimong recognised the value of the reserve, mainly due to their illegal incursions into the reserve. Ga-Kama residents alleged that the current “management strategies” impeded the people from accessing the reserve to collect resources. They reckoned that due to the prevailing high levels of poverty and unemployment in the affected villages they should be allowed access to the natural resources of the reserve.

1.4 Impacts of laws and rules of the reserve on residents

Most of the respondents from Badimong were not threatened by the rules implemented on the reserve; they survived without the resources from the reserve. Ga-Kama residents were, however, negatively affected by the rules because they can no longer graze their cattle on it and if they want to pass through the reserve to visit their relatives on the opposite side, they have to pay an entrance fee.

Table 2. Results of ethnobotanical survey.

Question	Badimong	Ga-Kama
1. Do you have any interaction with the reserve?	YES – 60% Fishing, aesthetic value, hunting and wood collection NO – 40%	YES – 53% fishing, aesthetic value NO – 47%
2. How do you view your interaction?	BAD – 10 % GOOD – 90%	BAD – 20% GOOD – 80%
3. Do you want to be part of the Reserve? 3.1 In what capacity?	YES – 93% NO – 7% Game 20% Agriculture/Grazing 14% Zoo 14% Hotel 7% Ecotourism 7% Park 7%	YES – 53% NO – 47% Game 20% Hotel 20% Agriculture/Grazing 7% Zoo/Museum 7% Entertainment 7%
4. Do you have any expectations from the reserve?	YES – 93% NO – 7% Ranger, Monitoring officer, other employment.	YES – 53% NO – 47% Ranger, Education officer, other employment
5. Do the existing rules pose any threat to you?	YES – 33% NO – 67%	YES – 47% NO – 53%
6. Will you change the rules if you were the manager?	YES – 27% NO – 73%	YES – 33% NO – 67%
7. Recommendations	Add more animals, Utilise the land for agricultural reasons	Strengthen security, reduce poverty.

2 Floristic survey

2.1 Phytosociological table

2.2 Classification

The vegetation of the Turfloop Nature Reserve can be divided into five main plant communities (Figure 15), some with a number of sub-communities and variants.

The communities identified include the:

1. *Acacia karroo* – Communities
    - 1.1 *Acacia karroo* - *Chloris gayana* Sub-community
        - 1.1.1 *Acacia karroo* - *Phragmites australis* Variant
    - 1.2 *Acacia karroo* - *Aristida congesta* Sub-community
        - 1.2.1 *Acacia karroo* - *Panicum maximum* Variant
2. *Euphorbia ingens* Community
3. *Eragrostis rigidior - Acacia hebeclada* Community
4. *Acacia robusta* Community
5. *Acacia tortilis - Pogonarthria squarrosa* Communities
    - 5.1 *Acacia tortilis* - *Pogonarthria squarrosa* - *Lippia javanica* Sub - community
        - 5.1.1 *Acacia tortilis* - *Pogonarthria squarrosa* - *Dicerocaryum eriocarpum* Variant
    - 5.2 *Acacia tortilis* - *Pogonarthria squarrosa* - *Aloe marlothii* Sub - community
        - 5.2.1 *Acacia tortilis* - *Pogonarthria squarrosa* - *Eragrostis gummiflua* Variant

Table 3. Phytosociological table of the Turfloop Nature Reserve

RELEVES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
COMMUNITIES	1											2		3						4			5										
	1.1																								5.1								
			1.2																												5.2		
							1.2.1																5.1.1										
			1.1.1																														
																									5.2.1								
SPECIES GROUP A																																	
Chloris gayana	+		3		1	+		1			a											1											
Acrotome inflata	+	+	1	+	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asparagus africanus	r	+	1	r	.	.		.	.	.	r	.	+	+	+	.	+	+	+	.	r	.	.	.	.	+	.	.	.	.	.	.	.
Cucumis zeyheri	a	.	+	+	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Tagetes minuta	1	r	+	+	+	+				r	1			1						+	+										+		
SPECIES GROUP B																																	
Panicum maximum	+	+	.	.	+	.	1	.	+	.	+	a	.	+	.	.	.	+	+	1	.	.	1	+	.		3		3	3	3	+		3
Schkuhria pinnata	r	.	.	.	.	.	a	.	.	1	1	.	.	1	.	.	.	.	.	.	.	.	+	.	b	+	.	.	.	.	.	.	.	.
Themeda trianda	r						1		3		1			1	a		1		1	+							+						
Soporobolus africanus							1	+		a	a																						
Eragrostis superba	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Euclea crispa	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Sansevieria aethiopica	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis congesta	+	.	.	.	.	.	.	.	.	.	3	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SPECIES GROUP C																																	
Lippia javanica		r			+									+		1	r	+		+			a	a			1	+			1			+
Felicia merxmuelleri	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.
Lantana rugosa	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	+	1	1	.	1	.	r	.	.	.
SPECIES GROUP D																																	
Phragmites australis	.	.	4	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	1	.	.	.	.	.	.	.	.
Achyranthes aspera	.	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyperus sexangularis	.	.	3	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Digitaria eriantha	.	.	3	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	1	+	.	1	.	.	.	.	.	.	.	.
SPECIES GROUP E																																	
Aristida congesta	.	.	r	+	+	1	1	.	1	+	r	.	+	1	.	.	a	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Heteropogon contortus	.	.	.		1	r	+	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio inaequidens	+										+																						
SPECIES GROUP F																																	
Acacia robusta	.	.	.	.	a	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	r	r	.	.	.	.
Ehretia rigida	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	r	r	.	.	.	.	.	.	.	.	.	.	.
Acrotome hispida	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.
Convolvulus sagittatus	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cynodon dactylon	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	+	.	.	.	.	.	.	.	.
Dicoma zeyheri	.	.	.	.	r	.	+	.	.		+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Grewia flava	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Indigofera melanadelina	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	8
Khyphocarpa angustifolia	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Maytenus senegalensis	.	.	.	.		.		.	.	.	.	.	.	.	.	.	.	.	.	1	.	r	.	+	+	.	.	.	.	.	.	.	.
SPECIES GROUP G																																	
Aloe marlothii							+					1			1			3	3						+			1	+	+	b	a	r	r
Eragrostis curvula	.	.	.	.	.	1	.	.	1	.	.	.	.	.	1	+	1	.	.	.	1	b	.	.		a		3	.	.	+	3	.	+
Solanum panduriforme	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Xanthium strumarium	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	r	.	.
SPECIES GROUP H																																	
Dicerocaryum eriocarpum	1	+			1				r					+										1	b								
Melinis repens	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+		1	.	a	.	.	.	.	.	.	.
Tinnea rodesiana	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.r	.	.	.	.	.	.	.	.	.	.
SPECIES GROUP I																																	
Acacia karroo			r		3	a	1		a		3	.	a		a	a		1	a	3	a	a						b	b		r		b
Sesbania sesban	+	+	.	.	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Setaria incrassata	+	+	.	.	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geigeria burkei			+						+		r																						
SPECIES GROUP J																																	
Euphorbia ingens												a	+														1			4			
Combretum mollle	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Crotolaria grantana	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	a	.	.	.
Eragrostis racemosa	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Maytenus undata	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pappea capensis	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crotolaria hispida	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Opuntia ficus- indica	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phyllobolus congestus	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SPECIES GROUP K																																	
Eragrostis rigidior		4			b			5		a				b	4	b	a	b	b									4	3				
Acacia hebeclada				a										1	1	a	1			a			b	b			a						
Maytenus heterophylla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+				.	.	.	.	.	.	a	.	.	.	a
Xanthium spinosum	1		+											r	r			r	r	1													
Crassula sarcocaulis	.	+	.	.	.	.	.	.	.	.	.	a		r	r	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bidens bipinnata														r	r		+		r														

Bidens pilosa				1	+				+										a			1					+		+				+				+						1		1														
Aspathalus suaveolens																			+																																								
Becium angustifolium					r														+						r				+																														
Dicrostachys cinerea																			+				r																																r				
Diospyros lyciodes					r														+																																								
Eragrostis trichophora																			+				r						r																														
Flaveria bidentis																			+																																								
Kalanchoe rotundifolia							r												r				r																																				
Maytenus tenuispina																			+																																								
Panicum coloratum	r																		+								r																																
Psedognaphalium luteo- albu																			+				r																																				
Rhoicissus tridentata							r												+						r																																		
Sesamum triphyllum																			+				r				+		+																														
Sporobolus festivus																			+																																								
Panicum ecklonii																			+																																								
Pogonophora africana	r																		+				r				r																																
Hyparrhenia dissoluta																										1																																	
Clerodendrum glabrum																												1		1																													
Euclea crispa																											a																																
Vernonia fastigiata																											r			1														+															
SPECIES GROUP L																																																												
Acacia tortilis					a		1							+		1																						1			r			b				1	a		a				r				a
Pogonarthria squarrosa					+								1		+								+		+												a						3	b				3		1	+					1			
Themeda trianda																												1																		r									r				r
Boscia albitrunca																																1												+									r						
Catha edulis																															+															r													
Senecio burchellii																							r																		r												r						
Senecio longiflorus												r																											r										r										
Peltophorum africanum																															a																				r								
Ziziphus mucronata																			r																																				+				
Conyza floribunda																			r																																						+		r
SPECIES GROUP M																																																											
Eragrostis gummiflua																																				1	a				r							3			+				a				
Dicoma capensis																																											5										+						
Melinis repens																																											5																
Rhus pyroides																																											5																
Setaria sphacelata																																											5																
Waltheria indica																																											5																
Zinnia peruviana																																											5																
Anthospermum aethiopicum																																												+															
Geissorhiza burchelli																																													1														
Senecio babertonicus																																													1									1			r		
Schmidtia pappophoroides																																																1											
Putterlickia speices																																																		1									
Indigofera filifolia																																																				1							
Terminalia prunioides																																																				1					r		
Indigofera spinescens																																																				1							
Brachylaena rotundata																																																					a						
Ficus thonningii																																																					b						
Rhynchosia minima																																																						1					
Senna septemtrionalis																																																					a			1			
Vangueria infausta																																																						1					
Aloe ammophila																						1																								+													
Carissa bispinosa																					+																				r								r								r		
Sansevieria hyacinthoides																						1																											r								+		
Aptosimum procumbens																																																	+				+						
Thecacoris trichogyne																																									+																		
Euchaetis cristagali																																																	r										
Rhynchelytrum repens																																														r													
Rhus leptodictya																							r				+																	r															
Croton gratissimus																																									+																		
Gymnosporia buxifolia																																																					+						
Gymnosporia senegalensis																																																					+						
Gymnosporia tenuispina																																																	+										
Hyacinthoides angustiflora																																																					+						
Sida rhombifolia																																									r																		

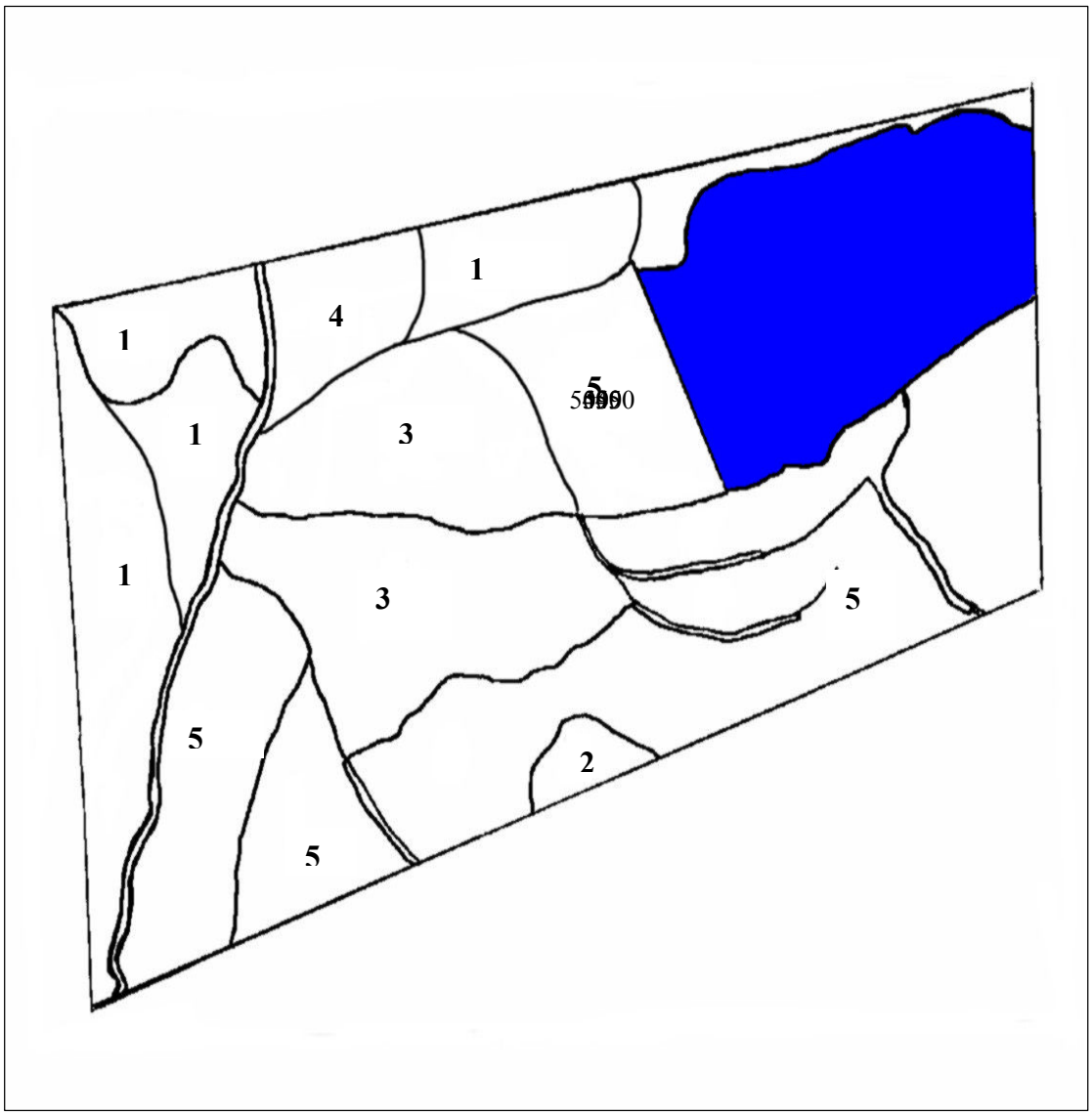

Figure 15. Communities of the TNR (numbers correspond with the identified communities).

2.3 Vegetation description

1. *Acacia karroo* Community

The community is represented by relevés 3, 4, 5, 6, 8, 9 and 11 (Figure 16), situated on a 4% gradient north west-facing slope, comprising dark reddish brown soils.

This community is a fairly open savanna, abundantly vegetated with many large trees and shrubs. The tree stratum has relatively high species diversity. The dorminant species is *Acacia karroo*, other conspicuous trees being *Acacia tortilis* and *A. hebeclada* with an average height of 3 to 3.5 m. Patches of herbs and grasses are found in depressions of the topography. Shrubs are on average 0.8 m high and the herbaceous layer 40 cm. Less than 25% of the area is not vegetated.

The area is bordered by the *Acacia tortilis* community. The community has less than 2% litter.

The community has a canopy cover of 75%. The tree stratum contributes about 30% to canopy cover, the shrub stratum approximately 6%, and the herb stratum about 10%.

The community is represented by 7 relevés in which an average of 13 species was recorded. Diagnostic species are listed in species group I of Table 3. The associated trees include *Acacia tortilis, Aloe marlothii*, *Euclea crispa, Gymnosporia buxifolia* and *Maytenus senegalensis*. The shrub stratum is represented by *Asparagus africanus*, *Lantana rugosa* and *Lippia javanica*. The herb stratum consists of: *Tagetes minuta*, *Cucumis zeyheri, Bidens pilosa* and *Schkuhria pinnata*. The grass stratum consists of *Aristida congesta, Eragrostis rigidior*, *Panicum maximum* and *Themeda trianda*.

The *Acacia karroo* community is represented by two sub-communities: *Acacia karroo- Chloris gayana* and *Acacia karroo- Aristida congesta*.

Figure 16. *Acacia karroo* Community.

1.1 *Acacia karroo* - *Chloris gayana* Sub- community

The Sub-community is represented by relevés 1, 3, 4, 5 and 21, situated on north-facing slope with an averaged gradient of 3%, comprising dark reddish brown soils.

This Sub-community is densely vegetated with many shrubs. Less than 10% of the area is unpopulated. The tree stratum has relatively low species diversity, with *Acacia karroo* being the most conspicuous at 4 m in height. This Sub-community is represented by shrubs with an average height of 1 m and a herbaceous layer with an average height of 1. 3 m.

The area is bordered by the *Acacia robusta* and *Acacia tortilis* communities. This Sub-community has less than 1% litter. The Sub-community has a total canopy cover of about 90%. The tree stratum contributes 10% to canopy cover, the shrub stratum 15%, herb layer 65%.

The Sub-community is represented by 5 relevés in which an average of 16 species was recorded. The diagnostic species are listed in species group A of Table 3. The associated tree is *Acacia karroo*. The shrub stratum includes the common species *Asparagus africanus* and *Lippia javanica* The associated herbs include *Bidens pilosa*, *Cucumis zeyheri* and *Tagetes minuta*. The associated grass is represented by *Panicum maximum*.

1.1.1 *Acacia karroo - Phragmites australis* Variant

This reed community is represented by relevés 4 and 7 (Figure 17). The community is situated on a north-facing slope with an averaged gradient of 2%, comprising a grey clay soil. This community covers most of the vlei (marsh) area below the Turfloop dam wall. This area is seasonally flooded and normally under water from December to May. The topography is disturbed by a number of man-made furrows.

Less than 5% of the area is unpopulated. This community is densely vegetated. Trees are absent. Shrubs consist exclusively of reed species. Although the community has a high abundance of pioneer species, much of the area has reached climax status. *Phragmites australis*, the dominant climax species, has an average height of between 2.0 and 2.5 m. *Cyperus sexangularis* is the second most dominant species. A plantation of *Eucalyptus perriniana*, an invasive species, borders the community on one side.

The community has a total canopy cover nearing 95%, with the shrub stratum contributing 1% of canopy cover and the herbaceous stratum 20%.

The community is represented by 2 relevés with an average of 10 species each. Diagnostic species are listed in species group D of Table 3. The associated shrub is *Asparagus africanus*. Associated herbs include *Acrotome inflata, Achyranthes aspera, Bidens pilosa, Cucumis zeyheri, Tagetes minuta* and *Xanthium strumarium*. *Digitaria eriantha* and *Chloris gayana* are associated grasses.

Figure 17. The *Acacia karroo- Phragmites australis* Variant. A community of *Acacia tortilis* is visible in the background.

1.2 *Acacia karroo - Aristida congesta* Sub-community

The Sub-community is represented by relevés 3, 4, 5, 6, 7, 9, 10 and 11, situated on a north-facing slope with an averaged gradient of 5%, comprising dark reddish brown soils.

This Sub-community is sparsely vegetated with many shrubs, herbs and less trees. Less than 35% of the area is unpopulated. The tree stratum has a relatively low species diversity, with *Acacia karroo* being the most conspicuous at 3 m in height. This community is represented by shrubs with an average height of 0. 6 m and herbaceous layer with an average height of 0. 5 m.

The area is bordered by the *Acacia tortilis* and *Acacia robusta* communities. This Sub-community has less than 5% litter.

The Sub-community have a total canopy cover of about 65%. The tree stratum contributes 20% to canopy cover, the shrub stratum 5% and the herb layer 40%.

The Sub-community is represented by 8 relevés in which an average of 19 species was recorded. The diagnostic species are listed in species group E of Table 3. The associated tree is *Acacia karroo*. The shrub stratum includes the common species *Terminalia prunoides*. The associated herbs include *Tagetes minuta*, *Acrotome inflata, Schkuhria pinnata.* Associated shrubs include: *Pragmatism australis* and *Cyperus senegalenses* while associated grasses are represented by: *Digitaria eriantha*, *Sporobulus africanus* and *Eragrostis congesta*.

1.2.1 *Acacia karroo - Panicum maximum* Variant

The variant is represented by relevés 7, 8 and 16 (Figure 18), situated on a north-facing slope of 3 % gradient, consisting of dark reddish sandy soils.

This community is densely vegetated with big trees and shrubs. Less than 20% of the area is unpopulated. The tree stratum has a relatively high species diversity. Trees are abundant and large with the most conspicuous being *Acacia karroo* and *A. hebeclada* with an average height of 3 to 5 m. Patches of herbs and grasses are found in slight indentations on the soil surface. Shrubs have an average height of 1.5 m and the herbaceous layer is on average 0. 35 m high. *Panicum maximum* is a conspicuous grass species.

The area is surrounded by the *Acacia tortilis* and *Acacia robusta* community. This sub-community has less than one percent of litter.

The *Acacia karroo* - *Panicum maximum* Variant have a total canopy cover of about 80%. The tree stratum contributes 30% to the total canopy cover, and the shrub and herb stratums 10% each.

The community is represented by 3 relevés in which an average of 9 species each was recorded. Diagnostic species are listed in species group B Table 3. The associated trees are *Acacia hebeclada*, *A. tortilis, Aloe marlothii* and *Gymnosporia*

buxifolia. *Dicerocaryum eriocarpum* is an associated herb. The following are associated shrubs: *Lippia javanica* and *Asparagus africanus*. *Eragrostis rigidior* and *Sporobolus africanus* are diagnostic grasses.

Figure 18. *Acacia karroo* - *Panicum maximum* Variant.

2. *Euphorbia ingens* Community

This community represents the Mamabolo Mountain Bushveld. The community is represented by relevés 8 and 12 (Figure 19), situated on a 50% gradient north facing-slope, consisting of dark reddish sandy soils.

This community is densely vegetated with a large number of big trees and shrubs. Less than 35% of the area is unpopulated. The community has a low tree and shrub diversity. The dominant tree is *Euphorbia ingens.* Another conspicuous species is *Aloe marlothii,* with an average height of 7 m. This community is represented by shrubs with an average height of 1 m and a herb stratum which is on average 55 cm high.

Patches of herbs and grasses are found in depressions of the topography. This community has less than 2% litter. The area is bordered by the *Acacia tortilis* community.

The *Euphorbia ingens* community has a total canopy cover of about 65%. The tree stratum has canopy cover of 25% while the shrub stratum has canopy cover of 7%. The herb stratum has a canopy cover of about 4%.

The community is represented by 2 relevés in which average of 9 species each was recorded. The diagnostic species are listed in species group J of Table 3. Associated trees include *Acacia karroo*, *A. tortilis, Aloe marlothii, Combretum molle*, *Croton gratissimus*, *Carissa bispinosa*, *Ficus thonningii*, *Maytenus undata* and *Rhus leptodictya*. Associated shrubs include *Asparagus africanus* and *Euclea crispa*. Diagnostic herbs include *Acrotome inflata*, *Crassula sarcocaulis*, *Schkuhria pinnata*, *Vernonia fastigiata* and *Vangueria infausta*. Associated grasses include *Eragrostis congesta*, *E. curvula*, *E. gummiflua, Panicum maximum*, *Pogonarthria squarrosa*, *Themeda trianda and Sporobolus africanus.*

Figure 19. *Euphorbia ingens* Community situated on a granite outcrop.

3. *Eragrostis rigidior* Community

This sub-community is represented by relevés 14, 15, 16, 17, 18 and 19 (Figure 20), situated on a 4% gradient north-facing slope, consisting of dark reddish, sandy soils.

This community is abundantly and densely vegetated with large trees and shrubs. The tree stratum has a relatively high species diversity. The most conspicuous trees being *Acacia karroo* and *A. hebeclada*, with an average height of 3 to 3.5 m. *Panicum maximum* is a conspicuous grass species. Shrubs have an average height of 1 m and the herb stratum an average height of 25 cm. Patches of herbs and grasses are found in depressions of the topography. Less than 20% of the area is unpopulated.

The area is bordered by the *Acacia robusta* and *Acaciz tortilis* communities. The *Eragrostis rigidior* community has less than 1% of litter.

The community has a total average canopy cover of about 80%. The tree stratum has a canopy cover of about 30%, while the herb stratum and the shrub stratum each have canopy covers of about 5%.

The community is represented by 6 relevés with an average of 18 species each. The diagnostic species are listed in species group K of Table 3. Associated trees are *Acacia hebeclada*, *A. tortilis, Aloe marlothii* and *Gymnosporia buxifolia*. The following are associated shrubs: *Lippia javanica* and *Asparagus africanus*. *Panicum maximum*, *Pogonarthria squarrosa* and *Themeda trianda* are associated grass species.

Figure 20. The *Eragrostis rigidior* Community.

4. *Acacia robusta* Community

The community is represented by relevé 21 (Figure 21), situated on a 3% North West - facing gradient, composed of dark clay to loamy soils, at an altitude of 1272 m above sea level.

This community is densely vegetated with many shrubs and large and tall trees. Less than 30% of the area is unpopulated. The dorminating tree is *Acacia robusta.* The tree stratum has a relatively high species diversity, with *Acacia karroo* being the most conspicuous at 4 m in height. This community is represented by shrubs with an average height of 1 m and a herbaceous layer with an average height of 80 cm. Patches of herbs and grasses are found in depressions of the topography.

The area is bordered by the *Acacia karroo* Community. The *Acacia robusta* community has less than 1% of litter.

The community has a total canopy cover of about 70%. The tree stratum contributes 50% to canopy cover, the shrub stratum 1% and the shrub layer 5%.

The community is represented by 1 relevé in which an average of 8 species was recorded. The diagnostic species are listed in species group F of Table 3. The associated tree is *Acacia karroo*. The associated shrub stratum includes the common species *Asparagus africanus*. The associated herbs include *Bidens pilosa*, *Cucumis zeyheri* and *Tagetes minuta*, while associated grasses are represented by: *Eragrostis curvula* and *Aristida congesta*.

Figure 21. *Acacia robusta* Community.

5. The *Acacia tortilis - Pogonarthria squarrosa* Community

The community is represented by relevés 23, 25, 26, 27, 28, 29, 31 and 33 (Figure 22), situated on a north-facing slope with an average gradient of 4%. A dark reddish sandy soil is present.

This community is densely vegetated with numerous large trees and shrubs. Less than 25% of the area is unpopulated. The dorminant tree is *Acacia tortilis*. The tree stratum has relatively tall species, with *Acacia karroo* and *A. hebeclada* being very conspicuous. Average heights reached by these trees are between 3 and 5 m. *Pogonarthria squarrosa* occurs frequently. This community is represented by a shrub stratum with an average height of 1.7 m, and a herb stratum with an average height of 30 cm. Patches of forbs and grasses occur in the slight indentations of the topography.

The area is bordered by *Acacia karroo* community. The *Acacia tortilis -Pogonarthria squarrosa* community has less than 1% of litter.
The community has a total canopy cover of about 75%, with the tree and shrub stratums each contributing 30% to canopy cover. The herb stratum has a canopy cover of 15%.

The community is represented by 8 relevés in which an average of 13 species was recorded. The diagnostic species are listed in species group I of Table 3. Associated trees include *Acacia tortilis*, *A. karroo*, *A. robusta*, *Aloe marlothii*, *Gymnosporia buxifolia* and *Grewia flava*. *Lippia javanica* and *Lantana rugosa* are associated shrubs. The herb stratum consists of the following associated species: *Bidens pilosa*, *Cucumis zeyheri*, *Dicerocaryum eriocarpum*, *Schkuhria pinnata*, *Senecio barbertonicus*, *Tagetes minuta* and *Vernonia fastigiata*. *Eragrostis curvula*, *Panicum maximum*, *Pogonarthria squarrosa* and *Melenis repens* are associated species in the grass stratum.

Figure 22. *Acacia tortilis - Pogonarthria squarrosa* Community.

5.1 *Acacia tortilis - Pogonarthria squarrosa - Lippia javanica* Sub-community

The Sub-community is represented by relevés 23, 24, 26, 27 and 29, situated on north-facing slope with an averaged gradient of 3%, comprising dark reddish sandy soils.

This Sub-community is densely vegetated with shrubs, herbs and grasses. Less than 10% of the area is unpopulated. The tree stratum has relatively low species diversity, with *Acacia tortilis* being the most conspicuous at 2m in height. This Sub- community is represented by shrubs with an average height of 0. 8 m and herbaceous layer with an average height of 0. 4 m.

The area is bordered by the *Acacia karroo* and *Eragrostis rigidior* communities. The *Acacia tortilis - Pogonarthria squarrosa - Lippia javanica* Sub-community has less than 1% of litter.

The Sub-community has a total canopy cover of about 90%. The tree stratum contributes 30% to canopy cover, the shrub stratum 40%, herb layer 20%.

The Sub-community is represented by 5 relevés in which an average of 13 species was recorded. The diagnostic species are listed in species group C of Table 3. The associated tree is *Acacia tortilis, Acacia hebeclada*. The associated shrub stratum includes common species *Lantana rugosa.* The associated herbs include *Schkuhria pinnata* and *Dicerocaryum eriocarpum*. The associated grasses are represented by *Melenis repens, Eragrostis curvula, Eragrostis gummiflua, Digitaria eriantha, Panicum maximum* and *Pogonarthria squarrosa*.

5.1.1 *Acacia tortilis - Pogonarthria squarrosa - Dicerocaryum eriocarpum* Variant

The variant is represented by relevés 23 and 24, situated on South-facing slope with an averaged gradient of 4%, comprising dark reddish sandy soils.

This variant is densely vegetated with shrubs, herbs and grasses. Less than 20% of the area is unpopulated. The tree stratum has relatively low species diversity, with *Acacia tortilis* being the most conspicuous at 2m in height. This variant is represented by shrubs with an average height of 0. 4 m and herbaceous layer with an average height of 0. 7 m.

The area is bordered by the *Acacia karroo* and *Eragrostis rigidior* community. The *Acacia tortilis- Pogonarthria squarrosa- Dicerocaryum eriocarpum* variant has less than 1% of litter.

The variant has a total canopy cover of about 80%. The tree stratum contributes 30% to canopy cover, the shrub stratum 10%, herb layer 40%.

The variant is represented by 2 relevés in which an average of 10 species was recorded. The diagnostic species are listed in species group H of Table 3. The associated trees are *Acacia tortilis* and *Acacia hebeclada.* The associated shrub

stratum includes *Lippia javanica.* The associated herbs include *Schkuhria pinnata*, associated grasses is represented by *Eragrostis gummiflua, Panicum maximum* and *Pogonarthria squarrosa* being the most dominating species.

5.2 *Acacia tortilis - Pogonarthria squarrosa - Aloe marlothii* Sub-community

The Sub- community is represented by relevés 25, 27, 28, 29, 30, 31, 32 and 33 (Figure 23), situated on the gradual north facing slopes on dark reddish sandy soils. This community has an average slope of 18%.

This Sub- community is compactly vegetated with large trees and shrubs, less that 40% is unpopulated. Although the tree and shrub diversity is low and abundant of large trees occur in this community. The dominating tree is *Aloe marlothii.* The most conspicuous trees are *Acacia tortilis, Acacia karroo* and *A. hebeclada* with average heights of between 4 and 5 m. This Sub- community is represented by shrubs with an average height of 1 m and herbaceous layer with an average height of 46 cm. Patches of herbs and grasses found in slight indentations on the soil surface.

The surrounding area consists mostly of the *Acacia karroo* community. The *Acacia tortilis- Pogonarthria squarrosa - Aloe marlothii* Sub- community has less than 5% litter.

The Sub- community has a total canopy cover of about 60%. The tree stratum contributes 40% to canopy cover, the shrub stratum 7% and herb stratum 2%. The Sub- community is represented by 8 relevés in which average of 11 species each was recorded. Diagnostic species are listed in species group G of Table 3. Associated trees include *Acacia karroo*, *Brachylaena rotundata*, *Combretum molle*, *Croton gratissimus, Euphorbia ingens* and *Ficus thonningii*. Associated shrubs are represented by *Asparagus africanus* and *Euclea crispa*. Associated herbs include *Euchaetis cristagali*, *Rhynchosa minima, Senecio babertonicus, Senna septemtrionalis, Thecacoris trichogyne*, *Vangueria infausta* and *Vernonia fastigiata*. Associated grasses include *Eragrostis rigidior*, *E. gummiflua*, *Panicum maximum*, *Pogonarthria squarrosa* and *Themeda trianda*.

Figure 23. *Acacia tortilis - Pogonarthria squarrosa - Aloe marlothii* Sub - community.

5.2.1 *Acacia tortilis - Pogonarthria squarrosa - Eragrostis gummiflua* Variant

The variant is represented by relevés 25, 27 and 29, situated on north-facing slope with an averaged gradient of 5%, comprising dark reddish sandy soils.

This variant is densely vegetated with shrubs, herbs and grasses. Less than 20% of the area is unpopulated. The dorminating tree is *Acacia tortilis*. The tree stratum has relatively low species diversity, with *Rhus pyroides* being the most conspicuous at 2m in height. This variant is represented by shrubs with an average height of 1 m and herbaceous layer with an average height of 1. 4 m.

The area is bordered by the *Acacia karroo* community. The Acacia *tortilis-Pogonarthria squarrosa - Eragrostis gummiflua* variant has less than 1% litter.

The variant has a total canopy cover of about 80%. The tree stratum contributes 10% to canopy cover, the shrub stratum 30% and herb layer 40%.

The variant is represented by 3 relevés in which an average of 10 species was recorded. The diagnostic species are listed in species group M of Table 3. The associated tree is *Acacia tortilis. Setaria sephacelata, Waltheria indica* and *Zinnia peruviana* also occur. The associated shrub stratum includes common species such as *Lantana* rugosa, and *Lippia javanica* The associated herbs include *Bidens pilosa* and *Schkuhria pinnata*, while associated grasses are represented by *Melinis repens, Eragrostis curvula, Cynodon dactylon, Digitaria eriantha* and *Pogonarthria squarrosa*

3. Exotic, invasive and Red Data species

The following exotic plant species were found at the TNR: *Bidens pilosa, Opuntia ficus-indica* (Figure 24)*, Phragmites australis, Schkuhria pinnata, Sesbania sesban, Tagetes minuta* and *Xanthium strumarium.* The exotic species were found in 80% of the sampled plots. Their abundance ranged from single individuals to 50% of the sample plots, respectively.

Figure 24. *Opuntia ficus-indica* under biological control of *Cactoblastis cactorum*.

Only *Eucalyptus perriniana* (Figure 25), as an invasive species, were recorded. These large trees were introduced a long time ago, to serve as a wind-break. No Red Data species were recorded on the TNR.

Figure 25. A plantation of *Eucalyptus perriniana*.

4. Medicinal species

The following species with medicinal value were found on the TNR:
Acacia karroo, A. tortilis, Aloe marlothii, Boscia albitrunca, Clerodendrum glabrum, Combretum molle, Croton gratissimus, Dichrostachys cinerea, Dicoma capensis, Diospyros lyciodes, Ehretia rigida, Euclea crispa, Euphorbia ingens, Grewia flava, Gymnosporia senegalenses, G. tenuispina, G. buxifolia, Hyacinthoides angustiflora, Lippia javanica, Lantana rugosa, Pappea capensis, Peltophorum africanum, Rhoicissus tridentata, Sansevieria aethiopica, Senna septemtrionalis, Tagetes minuta, Xanthium strumarium and *Ziziphus mucrunata.*

5. Rare species

The following species were recorded as single plants in some communities:
Acacia tortilis, Aloe marlothii, Asparagus africanus, *Bidens pilosa*, *Cucumis zeyheri*, *Dicoma zeyheri*, *Dicerocaryum eriocarpum, Dichrostachys cinerea, Ehretia rigida*, *Felicia merxmuelleri*, *Ficus indica, Indigofera melanadenia, Kalanchoe rotundifolia,*

Lantana rugosa, *Lippia javanica*, *Melenis repens, Senecio barbertonicus, Themeda trianda*, *Terminalia prunioides, Tagetes minuta*, *Schkuhria pinnata*, *Sida rhombifolia, Vernonia fastigiata,* and *Xanthium strumarium.*

6. Provincial conservation authorities

During the study period, officials from Department of Nature Conservation and Limpopo DFED were consulted, to enquire about existing management strategies employed on the TNR. The feedback showed that there is no formal management plan for the reserve.

CHAPTER 6

DISCUSSION

1. ETHNOBOTANICAL SURVEY

Establishment and maintenance of a rural residential area requires large amounts of natural resources, ranging from wood, water and food. Lack of electricity forces people to utilize natural resources in order to sustain their needs. The increase in the human population is directly proportional to an increase in demand for natural resources. The TNR is surrounded by under developed rural areas, which obtain resources illegally from the reserve, which in turn leads to a general deterioration of the reserve. This study has identified, with some concern, a serious lack of conservation knowledge in the residing population adjacent to the TNR.

1.1 Lack of conservation knowledge

Previous research (DEAT, 1997; CBD, 2001) indicated that a lack of conservation knowledge and information about the value of biodiversity are some of the main obstacles threatening biodiversity conservation, a fact also noted in this study. Lack of knowledge makes it difficult for the community to understand the necessity to conserve or manage resources (Cromhout, 2002). The fact that the majority of people in the sampled villages are illiterate makes it even more difficult for the community to implement conservation initiatives. Therefore, conservation education programmes are necessary to educate local people (young and old) about the need for conservation and its subsequent benefits. Such programmes need to target females and young ones as they constitute the majority of the illiterate people in the studied villages.

The implementation of programmes such as ABET are essential to improve the standard of education at village level. Villagers having more than 30 years of residency within their villages can serve as mentors for sharing indigenous knowledge due to their vast local knowledge and experience on the dynamics of the surrounding woodland (Cromhout, 2002).

1.2 Population pressure

The sustainability of natural conserved areas is hampered by high population pressure (Hackel, 1999) coupled with poverty (Gandar, 1983; Watson and Dlamini, 2003). The increase in the population also increases the demand for resources,

which, at some point, will ultimately exceed the supply and therefore negatively affect the surrounding resources (Lawes *et al*., 2004a). This was evident in this study. The major cause of high population growth in the study area and perhaps in all African countries is uncertain, but seems to be a result of a high fertility rate which can be linked to the level of socio-economic under-development. This is supported by a study (Lucas, 2003) in developing countries which predicted an increase in the number of people in the near future as the cohort of fertile females is getting larger each year.

The practice of polygamy and limited knowledge on birth control in rural areas will certainly increase human population growth. This will consequently reduce the surrounding resources, as people will demand more resources from their surroundings and more space for settlement and cultivation purposes. Badimong village population in 2005 to 2006 increased from 12 270 to 12 690, with that of Ga-Kama increasing from 2967 to 3068 (WSDP, 2006).

1.3 Economic characteristics

Large areas of South Africa's savannas are concentrated in the former homelands where poverty is common, high unemployment rates prevail and limited economic activities exist. The TNR is situated in the former homeland of Lebowa. The majority of people (72% - unpublished result from another study) in the study area, in particular females, are unemployed. It is thus with no surprise to determine that a large majority of residents from both sampled villages indicated that they would like to be formally employed on the reserve.

High unemployment is a widespread problem in most rural areas of South Africa. It is estimated that 70% of people in South Africa's rural areas are poor (UNCCD, 1994), with the population heavily dependent on natural resources (Shackleton *et al*., 2000; DME, 2003; DEDET, 2006). In the Bushbuckridge area, for example, a depressed economy has resulted in few opportunities for employment (DWAF, 2000) and an over-reliance on natural resources. Poverty leads to an over-utilisation of natural resources for short-term benefits (Rowe *et al*., 1992) and ultimately severe long-term degradation (Casey and Muir, 1986; Mac Neely *et al*., 1995), a predictable situation in the study area. This study suggests the initiation of natural resource management

projects at village level as an option to reduce degradation of the TNR. But, based on this study, the first people that should be employed in such projects are the unemployed women. Employing women would encourage their participation in sustainable practices, promote efficient use of wood and supplement household incomes.

1.4 Over-utilisation as the driving force

The main driving force of wood depletion on the TNR is the demand of firewood. The majority (84%) of the respondents in the villages use firewood for cooking and heating purposes (unpublished results from another study). This makes wood the primary source of energy for cooking and heating in the studied villages. A study in Malawi showed wood as the primary source of domestic energy in rural areas (Abbot and Lowore, 1999), while in Namibia, 85% of households (Erkkilä and Siiskonen, 1992) and between 95 and 100% in Zimbabwe (Mac Garry, 1987) use wood more than any other energy source for cooking and heating. It is also the main source of energy for most rural households in South Africa (Gandar, 1994; Hassan, 2002; DME, 2003). Despite the large-scale electrification drive in South Africa, firewood is still the primary source of energy for rural communities (Shackleton *et al*., 2004). The demand for firewood is predicted to rise by 50% in 2030 (MEA, 2004). Firewood use in the study area is far higher than the estimated one third of rural households in South Africa that rely on wood for energy supply (DWAF, 1996), which is indicative of the high levels of poverty and entrenched cultural aspects. Considering population growth and poverty, firewood demand in rural areas and thus on the TNR will probably increase in the future.

1.5 Villager's perceptions towards their participation in woodland management on the TNR

Barrow (1995) stated that people's attitudes and perceptions to modify the environment are not similar. Equally, studies conducted in Germany, Austria, and Switzerland showed that the environment is shaped by people's aspiration towards it (Schmithüsen *et al*., 1997). The attitude and perceptions of people toward their woodland determines its management, and a positive attitude and perception of people could result in better management of natural resources.

This study showed that villagers have a positive perception towards woodland management. A possible reason might be that they perceive natural resources as open access with everybody having the right to use it. The fact that access control to the TNR for residents from surrounding communities is nearly non-existent surely aid in this perception. Open access system has no exclusion rules and access to resource is open to anybody (Scoones and Matose, 1993). This perception has eventually led to an abuse and vandalism of resources, evident in many areas of South Africa (Lawes *et al*., 2004b). In contrast to open access system, common property natural resource management is viewed as an option for successful local management of natural resources (Scoones and Matose, 1993; Crouch and Edwards, 2004). Training of villagers and traditional leaders on common property natural resource management is essential, but such initiatives require full participation of villagers, which is currently lacking in most rural areas of South Africa and many rural parts of the world.

1.6 Conclusions

This study has provided some basic information on the usage and attitude of the communities adjacent to the TNR. Results indicate that the surrounding communities have a great interest in the reserve for various reasons (e.g. harvesting wood for firewood), and that they have inflicted serious damage to the reserve. Inclusive co-management strategies between DFED and the communities should be looked at in order to promote sustainable utilisation of the TNR by the surrounding communities. These strategies must be formulated, based on the National Environmental Management Biodiversity Act (see Chapter 2). Concurrently, an electric fence could be installed to prevent further uncontrollable damage by surrounding communities and other locals.

A general lack of conservation knowledge by the inhabitants of the surrounding communities was identified as a serious problem. It is suggested that a number of workshops be conducted at nearby community centres to inform inhabitants on the serious problems encountered at the reserve.

2. FLORISTIC SURVEY

2.1 Comparison with Bredenkamp and Van Vuuren (1977)

The current data can be directly compared with the data of Bredenkamp and Van Vuuren (1977) as both these studies used comparative methods. In contrast, data obtained via the DFED (1992) reports has value only in terms of the management strategies that were employed at that time.

The general structure of vegetation on the TNR has changed markedly with the formation of a number of new plant communities. Furthermore, no community has remained the same. The abundance of vegetation on the northern side of reserve has decreased by 50% since 1977, possibly due to severe unsustainable exploitation of resources by villagers from Badimong. This village is a mere 10 meters away from the reserve fence. This led to establishment of the *Aloe marlothii* Sub- community with the demise of *Acacia karroo* as the dominating species.

On the north-eastern side of the reserve there has been a general decline of *Acacia tortilis* since 1977, due to its over exploitation by villagers, and a concomitant increase of *Acacia hebeclada* and *A. robusta*. The structure of vegetation on this side of the reserve is characterised by a dense vegetation consisting mainly of *Acacia hebeclada* and *A. robusta*. The prohibition of harvesting by TNR officials has possibly resulted in this dense vegetation. Failure to monitor the threats of bush densification will limit resources for game on the reserve.

2.2 Communities

The communities recorded by Bredenkamp and Van Vuuren in 1977 is still present, with the exception being *Cynodon dactylon* grassveld community. However, a number of new communities were recorded in addition to those documented by Bredenkamp and Van Vuuren in 1977. These include the *Acacia robusta*, *Eragrostis rigidior – Acacia hebeclada* and *Euphorbia ingens* Communities. The introduction of these communities could be the result of anthropogenic and animal influences, climate change and soil moisture changes.

Due to changing environmental conditions (naturally or unnaturally induced), plant communities are constantly changing. On the TNR anthropogenic influences played a significant role in establishment of new communities. Continuous harvesting of one specific species in a community often result in a different stratum, dominated by species which were previously less abundant.

In the 1977 community survey of the TNR, Bredenkamp and Van Vuuren (1977) classified *A. robusta* as belonging to the *Acacia tortilis* community. Since then, *A. robusta* has come to dominate certain areas to such an extent that it now warrants its own community (see Chapter 5). Previously *A. robusta* occurred as a minor entity in the *A. tortilis* community in 1977. However, due to over harvesting of *A. tortilis* and *A. karroo* for firewood by villagers living adjacent to the TNR, these species have declined in their dominance of the landscape, resulting in *A. robusta* becoming dominant and forming its own community.

Villagers adjacent to the TNR illegally graze their cattle on the reserve. This has led to selective overgrazing on a number of grass species, with an ultimate effect on the community composition. The disappearance of the *Cynodon dactylon* grassveld community from the TNR since the 1977 survey of Bredenkamp and Van Vuuren (1977) can most probably be attributed to the influence of grazing pressure and poor management strategies.

The influence of climate change since the 1977 survey (Bredenkamp and Van Vuuren 1977) can also not be ruled out. Climate change may have an effect on species composition and abundance. On the TNR this is difficult to ascertain due to the continuous application of anthropogenic effects (grazing and harvesting of wood) compounded by the influence of game on the reserve. However, as Figures 6 and 8 (see Chapter 3) illustrate, it is generally becoming hotter, with a 0.5 - 0.9 ºC increase over the last 50 years. Mean annual rainfall (Figure 8) has also decreased over this period, with a significant decline of almost 78 mm or more than 14%. per year. Similarly, mean annual humidity has also declined by nearly 8.7%. A hotter, dryer climate is generally assumed to stimulate the growth of new grass species.

The increase in abundance of *Cyperus sexangularis* between 1977 and 2008 in the *Acacia karroo* community can most probably be attributed to above average rainfall and increase in soil moisture below the Turfloop dam. It is speculated that more water is filtering through the Turfloop dam since 1977 resulting in a wetter habitat, giving rise to more *Cyperus sexangularis.* Climate change may also play a role in the adjustment of soil moisture. However, at this stage no evidence is available to substantiate this.

2.3 Individual species

There have been the following changes in composition of the following plant species:

- An increase in *Acacia hebeclada* and *A. robusta*. These two species are not targeted by locals for firewood or for construction material. This has led to their increase and are currently dominating species on the TNR. *Acacia tortilis* and *A. karroo* were once dominant on the TNR, but members of these species have been systematically targeted by locals for firewood and for other purposes such as poles for construction.
- An increase of *Panicum maximum*, *Chloris gayana* and *Eragrostis rigidior* in the shade of trees and shrubs, as well as in the *Acacia karroo* riverine and *A. tortilis* community. Fire in the aforementioned communities and a generally above average rainy season during the study period contributed to an increase of the above mentioned species.
- An increase of *Cyperus sexangularis* in the *Acacia karroo* community. The increase of *Cyperus sexangularis* can possibly be attributed to the above average rainfall on the TNR in the two years preceding this study and increase in soil moisture below the Turfloop dam.
- An increase of *Aloe marlothii* and *Euphorbia ingens* on the granite outcrops and open areas near the outcrops. *Aloe marlothii* and *Euphorbia ingens* are mainly found on the northern side of the reserve. These species have no cultural and socio-economic value to villagers living adjacent to the TNR. Furthermore, no animal on the TNR utilize these species. This has led to an increase in their abundance.

There was a general increase of the abundance of the following weeds and hardy pioneers: *Aristida congesta, Bidens bipinnata, Bidens pilosa, Dicerocaryum eriocarpum Pogonarthria squarrosa, Schkuhria pinnata* and *Tagetes minuta*. Anthropogenic activities such as the scrapping of dirt roads and other disturbances such as trampling by cattle could account for the increase in the above mentioned species. Although not severe, there are indications of the presence of weeds in almost every community.

In contrast, there was a general decrease in the abundance of the following weeds and hardy pioneers: *Achyranthes aspera, Conyza floribunda, Cynodon dactylon, Geigeria burkei, Senecio burchellii*, *S. longiflorus* and *Xanthium spinosum.*

The following succulent and woody species were recorded during the 1977 study but are absent from the current study.

- Succulents : *Aloe greatheadii* and *A. cryptopoda.*
- Trees: *Acacia rehmanniana, Deverra burchelli* and *Scleocarya birrea*. Bad management practices could have led to a decrease in their abundance.

The species below were not recorded in 1977 but were found during the current study.

- Trees: *Combretum molle, Maytenus undata, M. tenuispina*, *Pappea capensis* and *Rhus leptodictya.*
- Shrubs: *Croton gratissimus, Indigofera melanadenia.*
- Herbs: *Acrotome hispida, Acrotome inflata, Becium angustifolium Bidens pilosa, Cucumis zeyeri, Convolvulus sagittatus, Dicerocaryum eriocarpus, Dicoma zeyheri, Flaveria bidentis, Kyphocarpa anqustifolia, Phyllobolus congestus, Pseudognaphaphalium luteo-album, Rhoicissus tridentata, Sesbania sesban, Tinnea rhodesiana* and *Sesamum triphyllum,*
- Grasses: *Chloris gayana, Eragrostis racemosa, E. trichophora, E. rigidio, Heteropogon contortus, Setaria incrassata, Panicum coloratum*, *P. ecklonii, Pogonophora africana* and *Sporobolus festivus.*
- Succulents: *Euphorbia ingens.*

A possible reason for the occurrence of a number of shrubs, herbs and grasses in this study that were absent from the 1977 study, might be due to 2006 - 2007 summer season which was an exceptional rainfall year for the study area. This exceptionally wet year resulted in numerous species occurring on the TNR, as well as a noticeable increase in vegetation cover. The vegetation became very dense due to the high rainfall.

2.4 Exotic species

Exotic plant species are organisms that are introduced into habitats where they are not native, and they are responsible for habitat alteration and degradation. These exotic plants are a major cause of biological diversity loss throughout the world and can thus be considered "biological pollutants" (Germishuizen and Meyer, 2003).

It is evident that the abundance of exotics increased between 1977 and 2006 (refer to section 3 of Chapter 5). Anthropogenic influences, ranging from trampling and wood cutting has resulted in the formation of bare soil vulnerable to the colonization of exotics and pioneers.

Activities to eradicate exotics on the reserve were carried out until 1992 by Limpopo DFED. Exotics were manually removed and cochineal was introduced on certain species (DFED, 1992). Because of the absence of reports by DFED, under whose management the TNR fall, it is uncertain if eradication procedures were still in operation from 1992 onwards.

In an effort to stop the spread of exotic species on the TNR, continuous monitoring efforts should be introduced. In order to remedy and determine extent of invasions, actions focusing on exotics are discussed in Chapter 7 with specific reference to *Bidens pilosa, Opuntia ficus-indica, Phragmites australis, Schkuhria pinnata, Sesbania sesban, Tagetes minuta* and *Xanthium strumarium.* Failure to eradicate the spread of exotics will most probably result in indigenous species being out competed. In the long term this could possibly have a negative impact on the biodiversity of the reserve.

2.5 Conservation of rare species on the Turfloop Nature Reserve

Rare species are the result of the ecosystem they inhabit which might be unusual or degraded, and as such are indicators of endangered ecosystems. They assist in determining which habitats require special corrective actions (Raven, 1981). Rare species and their habitats must also be conserved, because more often than not, it is not known what critical functions they may perform, now or in the future. Essential ecosystem services may be provided. They may be reservoirs of genetic diversity that will maintain sustainable food and commodity production. They may be required for other species or ecosystems to survive climate change or disturbances such as flood, fire or disease (Raven, 1981).

Distribution of single plants of a species or rare species (refer to section 5 of Chapter 5) on some of the survey communities on the TNR can be attributed to the following factors; environmental, geographical, soil disturbance, temperature, sampling inaccuracy e.g. size of the plot.

There are a number of rare species, in this study, which has reduced their abundances when compared to the findings of Bredenkamp and Van Vuuren (1977). These include *Dichrostachys cinerea, Ehretia rigida*, *Felicia merxmuelleri*, *Indigofera melanadenia, Kalanchoe rotundifolia, Lantana rugosa*, *Sida rhombifolia, Senecio barbertonicus,* and *Terminalia prunioides.* Possible reasons for their decline could be inaccurate sampling and/or a variety of anthropogenic factors (wood cutting, cattle and game trampling) and/or that the reserve has not been optimally managed.

A number of r (solitary) species were identified in the 1977 study that were not recorded in this study. These include: *Acacia permixta*, *Bothriochloa insulpta*, *Blepharis subvolubilis*, *Clematis brachiata*, *Crotalaria laburnifolia*, *Guilleminea densa*, *Hypoestes triflora*, *Indigofera circinnata*, *Sida cordifolia*, *Verbena officinalis* and *Wahlenbergia denticulata*. Possible reasons for their decline have been discussed above.

3. CONCLUSION

In this study, tree species like *Acacia karroo* and *A. tortilis* represent the woody climax species. *Eragrostis rigidior* represent the grass climax species on the TNR; this can possibly be associated with drought or bad management of the veld. The above climax situation was also observed by Bredenkamp and Van Vuuren in 1977. This indicates that the TNR has reached climax a long time ago.

The classification of the vegetation in the study area stressed the correlation between habitat and floristic composition of the communities as well as relationships between communities. Differences and variations in the vegetation can be ascribed to differences in geological formation, previous mismanagement, and high levels of poverty in the surrounding communities, anthropogenic influences and soil type.

4. RECOMMENDATIONS FOR FURTHER RESEARCH

The following topics are recommended for further research:

- The ethnobotanical study conducted was purposely limited in scope, as the main aim of this study rested with the vegetation survey, with the ethnobotanical study only providing ancillary information. It is thus proposed that a more complete socio-economic study on the communities surrounding the TNR to be made to fully explore areas of co-operation with the relevant authorities (e.g. LEDET, DWAF and DEDET).
- This study can be used as a basis to conduct a vegetation condition assessment in order to estimate the carrying capacity, which is necessary before a wildlife management program can be established. Due to the unreliable rainfall in the area, studies would need to be conducted in both the wet and dry seasons.
- No successional studies have been carried out in the TNR. Successional stages would provide valuable information on the various sere communities, which would aid management strategies better.
- A study on the vegetation surrounding the TNR would provide insight into the interaction between a managed system (TNR) and an unmanaged system

(communal land). This would highlight factors outside the TNR which play a pivotal role in the long-term sustainability of the Reserve.

- Veld monitoring programme with specific reference to carrying capacity.
- Game monitoring programme.
- Drought mitigation programme.
- Curling programme.
- Roads and water points plan.

CHAPTER 7

MANAGEMENT PLAN

1. INTRODUCTION

The following management plan for the TNR is proposed in accordance with the following working documents:

- Resource Inventory, Management and Development Proposals.
- Biodiversity Conservation, Policy and Strategy (see Chapter 1).
- National Environmental Management Act and Limpopo Environmental Management Act (see Chapter 2).
    - Owning Agency: Limpopo Tourism and Parks Board (LTPB).
- Standard for Management Plans for Provincial Nature Reserves in Limpopo Province.
    - Owning Agency: Department of Economic Development, Environment and Tourism.

The proposed management plan will assist with practical recommendations and strategies specifically tailored to the TNR. If correctly applied, the recommendations should reduce or at the very least minimise the negative impacts (anthropogenic and ecological) on the TNR, and stabilise the ecological condition of the TNR. Some of the recommendations might also be applicable to other small reserves and parks in the Province.

2 WORK PLAN

A management system should be implemented through the listed below steps. These steps do not necessarily follow one another, but can be implemented concurrently.

Step 1: Strategic discussion

It involves the 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 invited (Yeatman, 2004). This step helps in the generation of ideas on how the identified problems

could be solved. A management plan needs to state the benefits sharing mechanism and a time management plan. The roles and responsibilities of villagers, traditional authorities, municipalities 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. This need to cover the social, economic, environmental and policy issues affecting local people (CIFOR C and I Team, 1999; INR, 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 and 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 the available resources. The strategies need to aim at meeting the objectives of the plan and be cost effective, practicable, promote gender equity, informative and address benefits sharing mechanism and the socio-economic welfare of the local people. All stakeholders need to be available during this stage (DEAT, 1997).

Step 4: Evaluation

This is the process of valuating strategy to be implemented based on the information of 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 (ISRDS, 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 (UNCCD, 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 (DEAT, 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 (DEAT, 1997).

3 PRACTICAL MANAGEMENT RECOMMENDATIONS

3.1 Ethnobotanical recommendations

3.1.1 Initiation of community-based development projects

The major cause of resource utilization is the severe levels of poverty within rural communities. As such, initiation of community-based projects such as SMMEs can reduce over-utilisation of wood (CBD, 2001), which could lead to a balance between human and conservation needs (Hackel, 1999). However, lack of clear government policy regarding CBNRM, alienation of women and youth (Versfeld and Nduli, 1998)

and lack of CBNRM project information in the study area has resulted in the ineffective implementation of community-based conservation projects. The remedial actions to be taken include;

- CBNRM projects need to be a grassroots driven approach to empower the previously disadvantaged groups (poor, disabled, women and youth) (DEAT, 2003).
- Villagers need to have access to resources and ownership (DEAT, 2003), but avoid exclusive rights to single individuals (Scoones and Matose, 1993).
- Furthermore, there are steps that need to be followed during the implementation of CBNRM (DEAT, 2003). There should clearly defined guidelines for resource use by the community (Scoones and Matose, 1993).
- Funding for community projects such as bee keeping, indigenous fruit and food processing, wood crafting, alien invasive species eradication projects, brick making, sewing projects, nursery projects and eco-tourism projects.
- CBNRM need to be implemented as an integrated approach with relevant conservation agencies to source funds and with established institutional structures, preferable from the village level (Ostrom, 1992, cited by Von Maltitz and Shackleton, 2004).

3.1.2 Raising of environmental awareness

To reduce the damage on TNR environment, the level of illiteracy amongst members of the Ga-Kama and Badimong community should be minimised. Information can also be disseminated through workshops and community meetings (Skottke and Mauambeta, 2000). The widespread dissemination of information can furthermore be done through local media (radio, newspapers) (Diouf, 1995).

3.1.3 Electric fence

Turfloop Nature Reserve is surrounded by under developed villages on its southern and northern boundaries. It is strongly recommend that an electric fence be installed to reduce the various anthropogenic influences from these villages that lead to degradation of the land. The implementation of this recommendation must be formulated within general framework of the Environmental Conservation Act (refer to section 3 of Chapter 2).

3.1.4 Researchers and research promotion

Researchers play a crucial role in the idenfication 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). However, the work of researchers is not fully recognised, resulting in a need for cooperation between researchers, villagers and policy makers to address challenges facing environmental sustainability in South Africa.

In the luminosity of this study, the followings options are recommended:

a) Efficient monitoring and assessment of resources for sustainable utilization.
b) Initiation of community-based projects that aim at reducing poverty in rural areas.
c) Commitment and co-operation from the stakeholders (conservation departments, private sectors, traditional leaders and villagers) in ensuring equal share of benefits, skills and knowledge.
d) Stakeholders respect with regard to time, cost (value of money) and quality which gives rise to efficient sustainability.
e) Provision of funds to raise environmental awareness at village level.
f) Subsidisation of alternative sources for fuel, food and building material to reduce pressure on natural resources.
g) Implementation of government Batho-pele principles and conservation legislature at all level of stakeholders to accommodate all beneficiaries.

3.2 Floristic recommendations

3.2.1 Invasive and exotic species

Although the TNR has a relatively low number of invasive species, these species still require constant monitoring to avoid its spreading. For the TNR, the timed-meander method is suggested. This method is quick and ensures that most species will be found and vegetation patterns detected. It is important to make sure that all species are detected before they compete with the native ones. This method will detect invader species which were not recorded during the study period (Huebner, 2006).

The timed-meander method entails the walking of each site thoroughly (within the 2-ha area) for one hour noting the time every 10 minutes as new species are tallied. If the number of new species listed does not decrease to zero in the last 10 minutes of walking, additional time would be added. This is a plotless method; any variables based on plots will not be analyzed. This method sample 100% of each site. Importance values are calculated using relative cover for the herbs, shrubs, vines, relative cover and relative density for the tree (Goff *et al*., 1982).

3.2.2 Plant communities

The following are growing problematic aspects within the plant communities of the TNR:

1. Grasses with low grazing and ecological value.
2. Erosion.
3. Bush encroachment.

All the above aspects occur in all communities, but in different degrees. As a consequence of the uniqueness of the various plant communities together with the above-mentioned problematic aspects, specific management strategies will be needed. Recommendations are discussed in detail for each community in section 3.2.2.4

Sections 3.2.2.1 – 3.2.2.3 describe recommended methods to be followed when dealing with problems associated with grasses which have low grazing and ecological value, erosion and bush encroachment.

3.2.2.1 Burning as a management strategy to improve grazing and ecological status of grass

The condition of grass on the TNR together with the dominancy of species such as *Aristida congesta* and *Eragrostis rigidior is* apparent on the reserve. According to Van Oudtshoorn (1991) the above mentioned species are characterised by low grazing and ecological value. Although, there is improvement of grass status with the emergence of *Themeda trianda* and *Pogonarthria squarrosa* it will take time for the reserve to recover. Immediate remedial actions be taken to improve the grass component status.

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

In sour veld, fire serves to burn old, unpalatable and unacceptable growth left over from previous seasons which, if not removed, would tend to smother the plants so that they would become moribund. It stimulate out – of – season growth, for example in autumn, when there is little young forage available in the veld. This is an undesirable practice and autumn burning on sour veld areas is illegal in South Africa. Fire destroys parasites, e.g. ticks: Veld burning is seldom recommended for this purpose. Use of fire controls undesirable woody or herbaceous invaders that reduce the production of the grass layer. It Burns certain areas to induce rotational grazing, if applied correctly this method can be effective for game (Trollope, 1989).

In a study by Grunow and Grossman (1978), it was found that fire initially reduced grass production in the Sour Bushveld (*Burkea africana* veld). Moribund material was reduced by approximately 50% during the following season, but no effect on the total grass production could be found. Furthermore, Gandar (1982) indicate that grass species differed in their reaction to fire. Forage grasses such as *Brachiaria nigropedata* and *Panicum maximum* recovered faster than non forage grasses such as *Eragrostis pallens* and *Aristida* species, while the reaction of *Themeda triandra* and *Heteropogon contortus* to fire was determined by the season of burning (Davidson, 1950; Roux, 1969; Le Roux and Morris, 1977).

According to Trollope (1989) grass species are more sensitive to fire while they are actively growing. Results obtained at the University of Fort Hare (Trollope, 1989). indicated that no differences were observed in the grass component where a mid-winter burn and a burn directly after the spring rains were compared. Burning during the active growing season, however, had effect on grass species composition, basal

cover and grass production. West (1965) and Scott (1972) observed the same tendencies. Consequently, the state of dormancy of the grass layer is considered more important than the season of burning (Trollope, 1989).

Game has a definite preference for recently burnt veld, due to increased palatability of the young, fresh grass that grows after fire. It is therefore important that stocking rates are within the carrying capacity and that fairly large areas are burned. It is for this reason that grazing by domestic animals is not permissible on burned areas within 14 days after a burn (Envirodel, 2004).

The condition of grassveld deteriorates if it remains unutilised for any length of time. The frequency of burning depends on the production rate, which in turn is related to rainfall and the degree to which the veld is evenly utilised. The frequency varies form annually on unutilised high rainfall sourveld, to once every three to four years on mixed veld to even longer intervals (Bothma, 2002).

Veld burning in grassveld is justified mainly as a means of removing low – quality residual material form the sward. Burning should be so timed that the veld is able to recover in the shortest possible time. Veld which is burnt before the first spring rains remains bare and is therefore more susceptible to soil erosion by both wind and water. In some fire climax grassveld areas veld burning is allowed by law only during the six – week period before the expected commencement of the growing season (Trollope, 1984).

The type of fire which is required to remove accumulated unacceptable material is a less intense fire which burns downwind (head fire). Although headfires are generally less intense at ground level than fires which burn against the wind (backfires), the temperature between one and three metres above the soil surface is higher in headfires than in backfires. It has been suggested, therefore, that grass fires should be applied as headfires when the air temperature is below 20 ºC and relative air humidity is above 50% and if possible when the soil surface is moist. These conditions help reduce the intensity of the fire (Trollope, 1989).

A large enough area must also be burnt, to prevent localized overgrazing and as general rule no less than a quarter or third of a property should be burnt – this is applicable to veld that is rather homogenous (Bothma, 2002).

Burning program

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. Follow up burning should be done to release the grazing pressure from areas burnt during the previous year. Alternatively, preventative measures such as the closing of water points in or near burnt areas or higher intensities of game reductions should be put in place (Bothma, 2002).

Vegetation community approach

When veld is burnt, blocks containing similar vegetation types should preferably be burnt together, particularly in terms of palatability of the grazing – e.g. sand veld with sand veld, and turf veld with turf veld – to prevent overgrazing of burnt areas (Envirodel, 2004).

Other ecological considerations

Burning for management purposes has to be planned and executed with due consideration of other factors besides the readiness and needs of the veld to be burnt. Such factors include (Envirodel, 2004):

- Other management programs such monitoring that could be affected negatively or positively through burning of a certain area.
- Water point management – it might be necessary to close water points in burnt areas to limit the impact of grazers, particularly in areas of higher palatability.
- Bush encroachment and control operations – an area where woody plants have been or will be thinned out, will attract higher grazing pressure because game tend to prefer areas with an open structure. If such areas are burnt as well, it might lead to an increased grazing pressure resulting in overgrazing, particularly if area is small. The resulting overgrazing could lead to renewed encroachment of woody plants.

- Protection of unique, special, threatened habitats, animal communities, populations and bird breeding sites.

3.2.2.2 Erosion

The condition of erosion on the TNR is not intensive except for the big drainage lines in form of dongas, running from South to North and East to West. Small eroded patches are apparent on the northern side and the middle of the reserve. Failure to eradicate this condition could result in a serious setback; this fragmentation will also affect natural distribution of biotic diversity, cause disturbance of ecological processes and natural systems.

The main goal of erosion management is to establish vegetation cover on eroded areas, and effectively prevent further soil loss through the implementation of various appropriate techniques and procedures, such as branch packing. Branches are packed over a denuded area to encourage the establishment of plant cover. The recommended procedure for erosion control, land reclamation and maintenance of roads follows below.

Proposed procedure (Envirodel, 2004)

A. Identify erosion that has resulted (directly and indirectly) from soil disturbances, particularly those that are threatening rare, unique and valuable features of the reserve.
B. Map on an appropriate scale, all areas of accelerated soil loss.
C. Classify the extent of erosion into categories (e.g. donga, sheet erosion).
D. Evaluate the state of existing structures and measures implemented, using a data form (Addendum 4).
E. Conduct fixed-point photography.
F. Prioritize areas for management attention.
G. Determine the most suitable method of reclamation and carry out costing analysis.
H. Purchase the necessary equipment.
I. Implement reclamation methods.

J. Monitor the site using the prescribed data form (Addendum 3) as well as fixed point-point photography.

K. Reserve management inspect completed reclamation work or new erosion areas annually. Comments to be written onto a project data form. Each structure is to be rated for urgency of attention, according to criteria listed on the data form (Addendum 4) and graded according to the following scale;

   I. Structure inadequate/ fragile/ severely damaged and needs maintenance within financial year.

   II. Damage to structure observed, but not so damaged to replace within the current year. To be attended to within two years.

   III. No work required.

L. Annual work priorities are established according to the following guidelines:

   1. A grade structure

      1.1 A grade new work

   2. B grade structure

      2.1B grade new work

M. Reserve Manager write up report.

3.2.2.3 Bush encroachment

Du Toit (1972) referred to the problem of bush encroachment in the grassland areas of South Africa. The Bushveld of the Limpopo Province is approximately 9 million hectares in size, most of which is heavily encroached by a number of species (DEDET, 2006). Results obtained by Trollope (1974) indicated that bush encroachment causes a significant reduction in the grazing capacity of veld.

Bush encroachment on the TNR is not extensive, therefore herbicides can be utilised to obtain the maximum effect at low cost, and it is a rapid process that does not require mechanical treatment. The use of mechanical method can be harmful to the biodiversity and ecological functioning of the reserve because it causes soil erosion (Trollope, 1974). The method below will be used determined by the size of the site.

In a study by Jordaan (2003) each of the two sites reserved for the Savanna treatments was 100 m x 100 m (1 ha) in size. Arboricide was applied; savanna as a mixture of 1.5 litre savanna and 8.5 litre of water was applied, using a dosing gun to

apply one dose of 2 ml 0.5 m tree height. Where single tress occurs, they were treated. Where dense stands of G. flavescens were encountered, every second G. flavescens individual was treated. In total, 3.85 litre of mixture was applied. This method was quick and ensured that most species were treated (Jordaan, 2003).

A site, 0.5 ha in size, was used as a control, to determine regrowth. Trees were coppiced, using a brush cutter and chain saws. No arboricide was applied. During 1998 a further size, consisting of a 100 m x 2 m strip transect, was randomly laid out in the camp where the experimental sites were, but in an area where no arboricide or cutting treatment were done were done. This site was only monitored during March 1998. Thirteen heifers and a bull grazed the experimental area during the period 2 February 1998 to 31 March 1998 (Jordaan, 2003).

3.2.2.4 Plant community units

The concept of management units is used to simplify management and make it more cost effective. Similarities in terms of physical characteristics, vegetation and management needs are used to group areas together (LTPB, 2004). Similar and synchronised management actions and measures such as monitoring of veld condition, changes in tree densities in plant communities, monitoring of the distribution of game, rangeland production, burning and the placement of watering points, are then applied to such areas (Envirodel, 2004).

On TNR the broad vegetation units that were identified are discussed individually in terms of its relevant characteristics and management needs. Because this study does not include a faunal component (monitoring of the distribution of game, monitoring of rangeland production), it can therefore not express itself in areas such as the placement of watering points and utilisation of the various plant communities.

Acacia karroo Community

This community is in a good ecological condition with species of conservation importance for game. Anthropogenic influences resulted in a diverse habitat for animals comprising both open and dense bush. Burning of grass is essential in improving the grass status, moribund can be replaced with sweet grasses. Grass species that dominate the community generally have a low grazing and ecological

value. Fire can be used on this community to remove moribund grass and provide at least initially higher quality grass for consumption. The area could be managed by headfires. The proposed procedure as described under section 3.2.2.1 should be followed.

Erosion in the middle of the community is caused by multiple drainage lines. The eroded area could be managed by branch or stone packing. The proposed procedure as described under section 3.2.2.2 should be followed. Failure to stem this problem will ultimately lead to a loss of vegetation.

***Euphorbia ingens* Community**

This community is stable and functions optimally. No additional management actions need to be taken to improve its current status.

***Eragrostis rigidior – Acacia hebeclada* Community**

This community is in a good ecological condition. It should be protected from overgrazing.

***Acacia robusta* Community**

Although anthropogenic influences have resulted in a diverse habitat for animals with open and dense bush, there are no species of high grazing value. The ecological effect of burning would be the same as those discussed under the previous community.

Erosion (Figure 26) is becoming a problem in this community, especially in the middle of the community due to large drainage line coming from the south. The effect of this and possible solution have been highlighted in the *Acacia karroo* community.

Bush encroachment by *Terminalia prunioides,* although not a significant problem (5%) at this stage is occurring in the middle of the community. Failure to stem this can ultimately result in severe encroachment, which will result in the community being inaccessible for game and a loss of species diversity. The encroached area could be managed by use of chemicals. The method for managing bush encroachment is discussed in section 3.2.2.3.

Figure 26. Erosion in *Acacia robusta* Community

***Acacia tortilis - Pogonarthria squarrosa* Community**

This community as a whole is in a fair ecological condition with species of conservation importance for game. This community has a canopy cover of 75% which provides excellent shade for various game species. Future management practices should be cognisant of the value of shade to game species. This community consist of both closed and open areas.

The open areas are due to anthropogenic influences such as wood harvesting. This has resulted in a suitable habitat for animals. It is recommended, however, that further harvesting of wood should be strongly discouraged.

Burning of grass stratum can be an important tool for improving its status and for removing moribund grass in this community the area could be managed by headfires. The proposed procedure as described under section 3.2.2.1 should be followed.

Erosion is apparent in the middle of the community, due to a large drainage line coming from the south (Figure 27). Failure to stem this problem could eventually result in the ultimate removal of a large portion the vegetation and impede game movement. The eroded area could be managed by branch or stone packing.

Figure 27. Erosion in *Acacia tortilis – Pogonarthria squarrosa* Community.

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ADDENDUMS

ADDENDUM 1

Questionnaire

1.1 LOCAL PEOPLE

Personal details

Village:						Gender	Male	Female	
Date of interview:									
Years resident in village			< 1year		1-5		6-10	>10	
Age	< 18	18-30	31-50		51-70		>71		
Level of education		No formal schooling			Primary education		Secondary education		
Level of employment		Unemployed		Self employed		Government employed		Private sector	
Specify, if self employed:_____									
Monthly income		<R 1000		R1001 - 3000		R 3001 - 5000		> 5001	

1. Do you have any interaction with the Reserve?

Yes	No

If yes, specify type(s) of interaction _____

2. How do you view your interaction?

Bad	Good	Both

3. Do you want to be involved in the Reserve?

Yes	No

If yes, specify nature of involvement _____

4. Do you have any practical expectations with regard to the Reserve?

Yes	No

Ifyes, specify_____

5. Do the existing rules and possible fines pose any threat to you?

Yes	No

If yes, how (specify) _____

6. Is the Reserve important to you?

Yes	No

If yes, (specify in what capacity)

_____

7. Do you view the Reserve as a communal land?

Yes	No

If not, to whom do you think the Reserve belongs to? _____

8. Do you have any recommendations?

_____

_____

1.2 Traditional Leader
Personal details

Village:			Gender	Male	Female
Date of interview:					
Years resident in village			1-5	6-10	>10
Age	18-30	31-50	51-70	>71	
Level of education	No formal schooling		Primary education	Secondary education	
Level of employment	Unemployed	Self employed	Government employed	Private sector	
Specify, if self employed:_____					

1. Do have any interaction with the Reserve?

Yes	No

If yes, specify interaction(s) _____

2. How do you view your interaction?

Bad	Good	Both

3. Do you want to be involved in the Reserve?

Yes	No

If yes, specify nature of involvement _____

4. Do have any practical expectations with regard to the Reserve?

Yes	No

If yes, specify

_____

5. Is the Reserve important to you?

Yes	No

If yes, (specify in what capacity _____

6. Do you view the Reserve as a communal land?

Yes	No

If not, to whom do you think the Reserve belongs to? _____

7. Do you have any recommendations?

_____

_____

Thank you for your participation

END OF QUESTIONNAIRE

ADDENDUM 2

Braun – Blanquet vegetation data sheet

Relevé number:			
Date (yy/mm/dd):		Soil	
Photo no:		Soil form	
Photo direction (Bearing):		Soil depth (mm):	
Altitude (m):		Estimate % Clay (A-horizon):	
Stratigraphy:		Cover: Gravel -	
Aspect (Bearing):		Erosion category	
Petrology:		Cover: Small stones -	
Lithology:		Surface crusting:	
Slope (%):		Cover: Medium stones -	
Terrain unit		Cover: Large stones -	
Local topography:		Rock:	
Vegetation		Cover moss layer (%):	
Cover total (%):		Maximum height herbs (cm):	
Height (highest) trees (m):		Cover algae layer (%):	
Cover tree layer (%):		Maximum height cryptogams (mm):	
Height lowest trees (m):		Cover litter layer (%):	
Cover shrub layer (%):		Cover open water (%):	
Height (highest) shrubs (m):		Cover bare rock (%):	
Cover herb layer (%):			
Height lowest shrubs (m):		Cover lichen layer (%):	
Aver height (high) herbs (cm):		Aver height lowest herbs (cm):	
Remarks:			

BB values:

Sample no.		Date:		Photo:	
Grass		Forb		Woody	
Genu/spec	BB-Value	Genu/ spec	BB-Value	Genu/ spec	BB-Value

Frequency Table:

Genu/Spec	Tics	Genu/Spec	Tics

ADDENDUM 3

5.3.1.5 Erosion evaluation field form

Reserve:				**Date:**		**Priority area:**		
	Structure number							
Filter material								
Silt accumulation								
Sides								
Voorskoot(behind erosion structure)								
Plant growth								
General								
Degree								

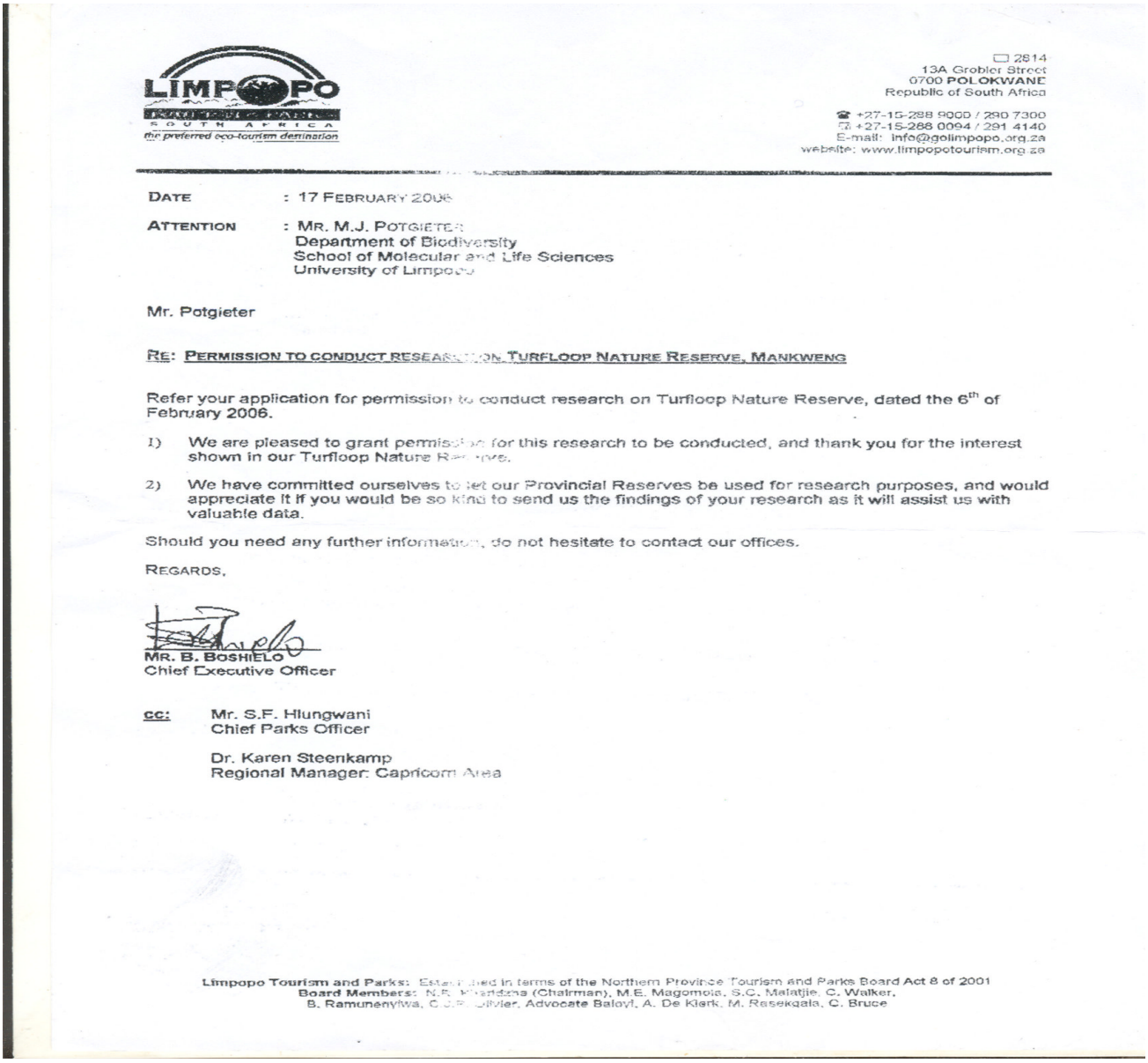
ADDENDUM 4

The degree of erosion (Envirodel, 2004).

Establishment of the degree of erosion	
Degree	**Description**
0	There are no signs of soil disturbances and the soil surface area is undamaged. No soil movement is noticeable, and small amounts of soil gathers in some areas. Above soil debris is seen frequently.
1	Slight signs of soil displacement. 1-10% of the surface area could be ascribed to sheet erosion. Soil loss is limited to open areas, and the general state of the soil surface is stable.
2	Soil movement is moderate and clearly visible. 11-40% of the areas top soil loss could ascribed to sheet erosion. A hard soil crust has formed and some plants are on top of a small soil base, and small mounds of soil are visible in open areas. Soil deposits can be seen in drainage lines or against small obstructions. Gravely small stones are exposed.
3	Extensive and active soil erosion is observed. 41-70% of the area' s soil loss could be ascribed to sheet erosion. There is an open erosion lane and active dongas are present in poor areas of the landscape. Vegetation on pedestals and soil deposits and debris are seen against obstructions and shrubs. Drainage lines are filled with soil deposits.
4	State of serious soil erosion. 71-100% of the area's soil loss could be ascribed to sheet erosion. Subsoil layers are exposed and on stony soils there are closed erosion lanes. The active dongas are expanding and extending. Large amounts of soil and debris are deposited in drainage lines. Wind erosion causes small dunes or hollow depressions in sandy soils.
5	Extreme situations on infertile, unattended lands or dunes and active topsoil displacement.

Addendum 5

Confirmation letter to undertake research on TNR by Limpopo Tourism and Parks in 2006.



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DATE : 17 FEBRUARY 2006

ATTENTION : MR. M.J. POTGIETER
Department of Biodiversity
School of Molecular and Life Sciences
University of Limpopo

Mr. Potgieter

RE: PERMISSION TO CONDUCT RESEARCH ON TURFLOOP NATURE RESERVE, MANKWENG

Refer your application for permission to conduct research on Turfloop Nature Reserve, dated the 6th of February 2006.

1) We are pleased to grant permission for this research to be conducted, and thank you for the interest shown in our Turfloop Nature Reserve.

2) We have committed ourselves to let our Provincial Reserves be used for research purposes, and would appreciate it if you would be so kind to send us the findings of your research as it will assist us with valuable data.

Should you need any further information, do not hesitate to contact our offices.

REGARDS,

MR. B. BOSHIELO
Chief Executive Officer

cc: Mr. S.F. Hlungwani
Chief Parks Officer

Dr. Karen Steenkamp
Regional Manager: Capricorn Area

Addendum 6

Confirmation letter to undertake research on TNR by Limpopo Department of Economic Development, Environment and Tourism in 2007.

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
ECONOMIC DEVELOPMENT, ENVIRONMENT & TOURISM

To : University of Limpopo Dept of Biodiversity School of Molecular and Life Sciences

From : Mokganya WL

Subject: **APPLICATION TO GAIN ACCESS INTO TURFLOOP NATURE RESERVE TO CONDUCT ECOLOGICAL AND ENVIRONMENTAL RESEARCH**

Date : 2007.12.12

ATTENTION: DR MJ POTGIETER

The Department of Economic Development, Environment and Tourism Branch: Provincial State Owned Nature Reserve acknowledges receipt of your application dated 2007.12.11 to conduct Ecological and Environmental Research in respect of Mr MM Mashatole (Student)

Permission is hereby granted on condition that after the completion of the research, documents or any information or strategies derived from the research can be made available to the department for future reference. Hope that all specialist studies will be conducted or undertaken in compliance with rules and regulations governing the reserve.

Regards

.....

SENIOR MANAGER
PROVINCIAL STATE OWNED NATURE RESERVE
DATE: 12/12/2007

Cnr Suid and Dorp Street, POLOKWANE, 0700, Private Bag X55464, POLOKWANE, 0700
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