URBAN BIOTOPE MAPPING AS FRAMEWORK FOR SPATIAL PLANNING IN MBOMBELA MUNICIPALITY, MPUMALANGA, SOUTH AFRICA

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Abstract

Destruction of natural areas in and around cities is taking place at an alarming rate, due to an increase in population densities in urban areas. Urbanization is therefore regarded as one of the most severe impacts on the environment. It follows that environmental protection must be considerably improved in urban areas. In South Africa, little research has been done on biota and their protection in urban environments and therefore urban planners and National and Local Governments are unaware of the biological and ecological value of urban open spaces. Biotope mapping focused on floristic and phytosociological features, as plant studies are relatively easily compared. Biotope studies could enhance urban biodiversity by including bird nesting and feeding guilds as well as the contribution of trees towards carbon storage. Biotope mapping of the vegetation in two Planning Areas namely A (Hazyview – densely populated / rural area) and H (Nelspruit – larger stands / urban area) of Mbombela was studied. The underlying aim of this study was to ensure that biodiversity and ecological aspects are sufficiently included in the planning of specific urban areas in the Mbombela Local Municipality. Ten clearly recognizable and ecologically interpretable plant communities were identified. The plant communities were described by using ordination and classification techniques and were grouped into 4 biotopes. The bird survey indicated that trees in natural open spaces are important for breeding sites and the carbon storage investigation indicated that tall trees with a large biomass are important to conserve. Mapping of specific biotopes were done according to ecological importance values of the vegetation, bird and habitat data. The evaluation of the biotopes indicated that biotopes in natural open spaces had a medium to high ecological value and should be rehabilitated, managed and protected. Recommendations were made according to the findings of this study and anthropogenic influences were incorporated to protect the environment from degradation. Maps of the Planning areas were included.

UITTREKSEL

Vernietiging van die natuurlike omgewing in en om stede en dorpe vind plaas teen 'n sorgwekkend tempo, hoofsaaklik as gevolg van 'n toename in bevolkingsgetalle in stedelike gebiede. Verstedeliking word dus as een van die ernstigste impakte op die omgewing beskou. Hieruit volg dat omgewingsbewaring aansienlik verbeter moet word in stedelike gebiede. Min navorsing is tot op hede nog in Suid Afrika gedoen op biota en die bewaring daarvan in stedelike omgewings wat tot gevolg het dat stads- en streeksbeplanners asook Nasionale en plaaslike regerings onbewus is van die biologiese en ekologiese waarde van stedelike oop ruimtes. Kartering van biotope fokus op die floristiese en fitososiologiese kenmerke want plantestudies is relatief maklik om te vergelyk. Hierdie biotoopstudies kan stedelike biodiversiteit verhoog deur die nesmaak - en voedingsgewoontes van voëls asook die bydrae van bome tot koolstofberging in te sluit. Die kartering van plantegroei in twee beplanningsgebiede nl. Beplanningsgebied A (Hazyview - hoë digtheid behuising, platteland) en Beplanningsgebied H (groter erwe, stedelike gebied) van Mbombela is bestudeer. Die onderliggende doel van hierdie studie was om te verseker dat biodiversiteit en ekologiese aspekte genoegsame aandag kry en ingesluit word in die beplanning van spesifieke stedelike gebiede in die Mbombela Plaaslike Munisipale Gebied. Tien duidelik herkenbare en ekologies interpreteerbare plantgemeenskappe is geïdentifiseer. Die plantgemeenskappe is bespreek deur gebruik te maak van ordinasie en klassifikasie tegnieke en is in 4 biotope gegroepeer. Die voëlopname het aangedui dat bome in natuurlike oop ruimtes belangrik is vir broeiplekke en die koolstofbergingsondersoek het aangedui dat hoë bome met 'n groot biomassa belangrik is om te bewaar. Kartering van spesifieke biotope is gedoen na aanleiding van die ekologiese belangrikheidswaardes van die plantegroei-, voël- en habitatdata. Die evaluering van die biotope het aangedui dat biotope in natuurlike oop ruimtes 'n medium tot hoë ekologiese waarde het en gerehabiliteer, bestuur en beskerm behoort te word. Aanbevelings is gemaak na aanleiding van die resultate van hierdie studie en antropogeniese invloede is ingesluit om die omgewing te beskerm teen degradasie. Kaarte van die beplanningsgebiede is ingesluit.

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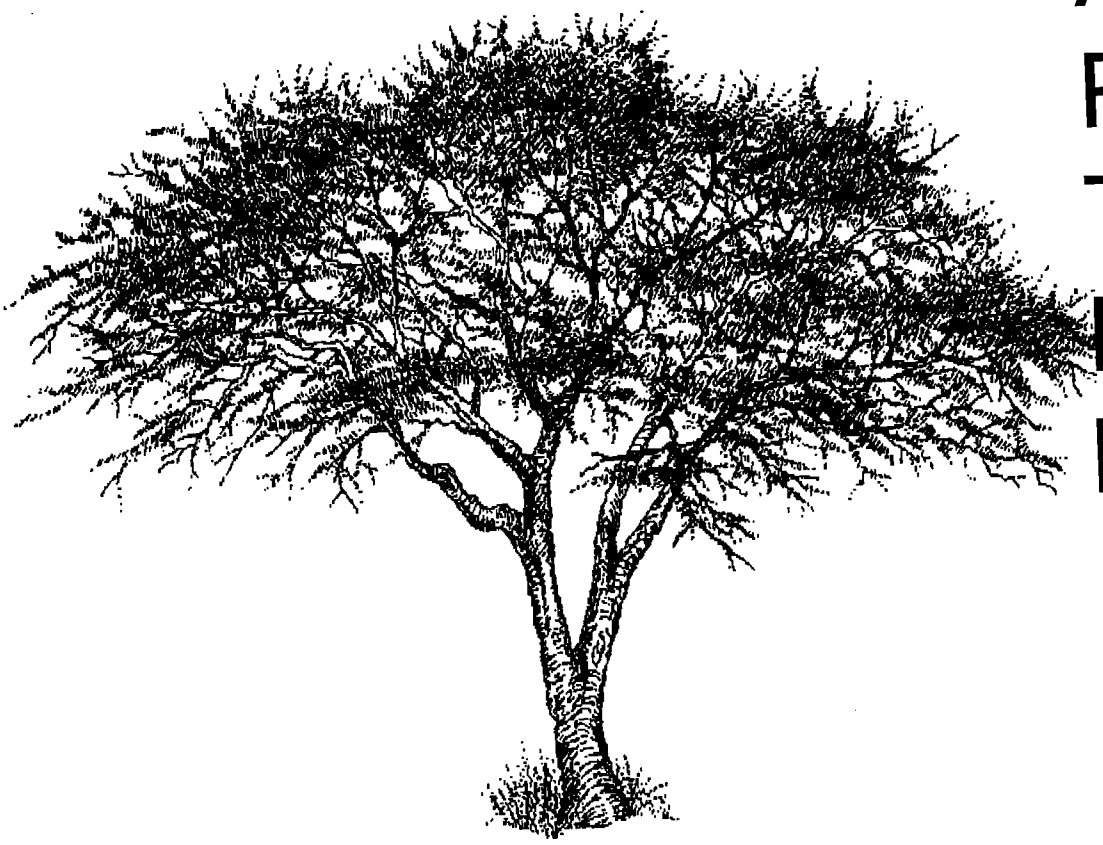
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ABBREVIATIONS

Avg	Average
BA	Basic Assessment
CBD	Central Business District
CO_2	Carbon dioxide
Dbh	Diameter measured at breast height
DFA	Development and Facility Act
ECA	Environmental Conservation Act,
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
Ha	hectares
IDP	Integrated Development Framework
IR	Importance Rating
IUCN	International Union for the Conservation of Nature and Natural Resources
LUMS	Land use Management Scheme
Masl	meters above see level
MLM	Mbombela Local Municipality
NEMA	National Environmental Management Act, Act 73 of 1998
NWA	National Water Act
Plant comm.	Plant community
SASS 4	South African Scoring System 4
SDF	Spatial Development Framework
SoER	State of Environment Report
TLC	Transitional Local Councils
TRC	Transitional Regional Councils
UN	United Nations
WFW	Working for Water

CHAPTER 1



Introduction

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INTRODUCTION

1.1 Urbanization

Urban areas are modified environments with large concentrations of people and buildings in a relatively small area that leads to many changes in the biosphere (McDonnell, 1997), which in turn influence the health and well-being of humans (Jackson, 2002). The major global impact of humans on the environment is the spread of urbanization into agricultural land and undisturbed natural areas (Pickett *et al.*, 1997). Urbanization is the process during which more people relocate to urban areas (Niemelä, 2000) and is a threat to natural habitats with increased conversions of land cover (Breuste, 1998; Niemelä, 1999; Zipperer *et al.,* 2000). Almost half of the world population is presently living in cities (Pickett *et al.,* 2001). Breuste (1998) stated that we are living in a century of rapid urbanization where many people rush to cities and according to Collins *et al.* (2000), more people will soon live in cities than in rural areas. Müller (1997) predicted that, with the current world population growth, 65% of the total population would live in urban areas by the year 2025.

According to Pickett *et al.* (2001) the developed nations have more urbanized populations. In the USA, for example, close to 80% of the population lives in urban areas. In the Federal Republic of Germany 12.7% of land is used for settlements or transport (Breuste, 1998). Australia (White *et al.*, 2005) and New Zeeland (Freeman & Buck, 2003) have highly urbanized populations, with 85% of their citizens living in urban areas. According to Pickett *et al.* (1997), the growth rate of the populations in the United States of America is increasing relatively slowly, but dramatically in urban areas.

The population of South Africa is estimated at 43 million with a growth rate of 2% per annum (Statistics South Africa, 2000). Cities in South Africa include an increasing number of informal settlements on the urban fringes and this sprawling has a huge impact on the natural areas in and around the cities (Cilliers, 2002). Expansion of informal settlements in the Western Cape, South Africa, threatens endemic species within the Cape Floristic Region in the Cape Metropolitan Area (Wood *et al.*, 1994).

Urbanization is a threat to the natural environment, although it can have both favourable and adverse effects on biotic communities (Niemelä, 2000). Human influences in cities create and maintain a variety of habitats that support high species diversity (Alvey, 2006; Cornelis & Hermy, 2004; Niemelä, 2002), but people use the attractive plants available at their nurseries that could consist of 70% exotics (Smith *et al.,* 2006). In urban landscapes, land-use planners

must understand how the proposed land-use change may affect ecological components as well as how social structures and processes are affected (Zipperer et al., 2000), because land-use decisions affect both ecological and social structures and processes. By minimizing impacts on the environment and limiting the use of natural resources, sustainable development would be possible (Florgård, 2000) and therefore ecological research in urban areas becomes more important for urban planning to improve the environment in which we live (Niemelä, 2002).

1.2 Human influences

The high population in cities have a negative effect on the environment and is also the reason for an increased temperature in cities. Cities are hotter than the surrounding natural areas and are described as urban heat islands by Manley (quoted by Gomez *et al.*, 1998) and Whitford *et al.* (2001). These urban heat islands result in a change in the atmosphere that could have an impact on biodiversity. Natural areas within cities will change because of human influence and plant species differ in their range of tolerance to the changing environment.

Humans are linked with the exploiting of natural resources and are responsible for the direct or indirect impact of air-borne toxicants and exotic species (Pickett *et al.*, 1997). They create habitats that did not exist before, water is diverted and the communities are manipulated. According to Collins *et al.* (2000), people mobilize some nutrients and deplete others in urban areas and these changes are harmful to some forms of life, including man himself. The following are specific examples of human influences:

1.2.1 Biodiversity

The expansion of urban areas and the types of urban land uses have an effect on biodiversity. According to Cornelis and Hermy (2004), parks in urban and suburban areas are important for the conservation of biodiversity. A study done on parks in Flanders, Belgium, by Cornelis and Hermy (2004) indicated that parks have a high biodiversity and could be considered as important "hotspots" of biodiversity in cities. Larger parks can contribute more to the conservation of biodiversity than smaller ones. Managed parks as well as gardens in cities make use of flora that is available at nurseries of which most are alien species. These managed parks and gardens interact with native biodiversity and a study done in Sheffield, UK on garden flora indicated that 70% of garden flora was alien species (Smith *et al.*, 2006). In South Africa, Roberts and Poynton (1985) found that exotic species are favoured in managed urban open spaces. Non-native species (alien species) have a harmful effect and are now regarded as one of the greatest threats to biological diversity worldwide (IUCN, 2000 quoted by Smith *et al.*, 2006).

The conservation of hills and ridges are extremely important because they have a topographical variety with high biodiversity caused by the interaction between climate and topography. A range of different aspects such as slopes, altitudes, soil or hydrological conditions characterize the spatial heterogeneity of ridges (Pfab, 2001). Variable microclimate conditions provide many habitats for invertebrate communities associated with high plant diversity (Strategic environmental Focus, 2006). Many Red Data or threatened plant and animal species inhabit hills and ridges. Sixty five percent of Red Data species in North West have been recorded on ridges (Abendroth, 2004) and 71% of Gauteng's endemic plant species occur on ridges (Pfab, 2001). Ridges may have a direct effect on the temperature, surface airflow and humidity as well as water inputs into wetlands. The experience of natural wildlife and the aesthetics accompanying it is a pleasure to most human beings (Abendroth, 2004). As these areas are seriously threatened by urbanization, it is important to gather more detailed information to be used for the establishment of guidelines in conserving hills and ridges in urban areas.

1.2.2 Air pollution and climate change

The energy balance in urban ecosystems is disturbed; there is little primary production and a low presence of decomposers, as plants no longer form the energy basis within the cities. The local climate is negatively influenced in cities where higher levels of air pollution, altered radiation and lower comparative humidity, reduced wind speed, and an increase in the annual mean precipitation may occur. The most important result of these effects is a rise in temperature (Müller, 1997) in urban areas, referred to as "urban heat islands" (Pickett *et al.*, 2001).

Together, the increasing uses of fossil fuel and deforestation have raised the atmospheric carbon (CO_2) concentration by 25% over the last 150 years. According to global models and preliminary measurements, these changes in the composition of the atmosphere have already begun raising the earth's average temperature which results in the development of the greenhouse effect (Akbari, 2002). Climate change and biological evolution are activities taking place over long periods of time, but with conditions in urban ecosystems, evolutionary and climate change are likely to be accelerated or enhanced (Collins *et al.*, 2000). Von Stülpnagel *et al.* (1990) stated that, with the presence of roads, buildings, pavements and other areas which absorb heat, temperatures in cities could be warmer than the surrounding areas.

Vegetation in cities has an ornamental function and regulates environmental functions such as retaining atmospheric water, contributing to evapotranspiration, reacting as a filter against pollution and regulating air, heat and damp within the urban surroundings (Gomez *et al.*, 1998). According to Nowak (1999), space may be available to plant trees in urban areas, but current

land uses prevent it. People frequently control the location and tree species in a specific environment and therefore also directly influence urban forest functions (Nowak, 1991).

1.2.3 Accumulation of carbon

Gas released into the atmosphere may affect the growth of wild or cultivated terrestrial plants. Studies in Phoenix indicated that carbon concentrations within the city centre are elevated to several times the global average (Collins *et al.*, 2000). The capacity of trees to filter particulates from urban air is based on leaf size and surface roughness (Pickett *et al.*, 2001; Gomez *et al.*, 1998). Trees an also store carbon through their growth process and this is a direct proportion of tree size (Nowak, 1991).

To understand vegetation-based carbon fluxes from a metropolitan region, it is necessary to know the current attributes of trees, shrubs, herbs and grasses in the different land use classes. The possible changes of these classes also need to be understood. This will allow the calculation of releases or sequestration of carbon (Rowntree, 1993). The purpose of urban vegetation measurements is linked to vegetation types and classes of land uses. According to Nowak (1991), carbon storage by trees is directly proportional to tree size.

1.3 Role of urban ecology

Urban ecosystems are described by Pickett *et al.* (2001) as those areas in which people live at high densities or where the built infrastructure covers a large proportion of the land surface. Urban ecology is defined by Sukopp and Weiler (1998) as the investigation of living organisms in relation to their environments within urban areas. According to Pickett *et al.* (2001), urban ecology has two distinct meanings where it emerges from a scientific side and from an urban planning perspective. In science, ecology refers to the studies of the distribution and abundance of organisms in and around cities as well as the biogeochemical budgets of urban areas. In planning the focus is on designing the environment for people and reducing the environmental impact.

Niemelä (2000) stated that ecologists become more concerned about the effects of humans on the natural ecosystem and that these studies originally started with human ecological problems that deal with human health as well as nature in cities. According to Gomez *et al.* (1998), the outcome of urban ecology is important to establish a balance between humans and the natural environment that leads to environmental protection within urban areas. According to the conference on nature conservation in 1992 in Rio de Janeiro and in 1996 in Istanbul (Habitat II), nature conservation in cities is enforced by the UN (Müller, 1997).

Ecosystems are multifaceted concepts where the physical environment and organisms in a specified area are functionally linked. With human interference, their products and the effects of their products in cities, integrated research is necessary (Pickett *et al.*, 1997). According to Picket *et al.* (1997), it is the task of urban ecologists to recognise humans as part of ecosystems within urban natural areas.

According to Cilliers *et al.* (2004), urban ecological studies could address the lack of descriptive ecological data, but long-term vegetation dynamics should be part of a study to give clear guidelines on the management of urban open spaces. The results of urban ecological research are useful for urban land management, nature conservation and pollution control (Cilliers & Bredenkamp, 1998), but this ecological information has to be in a format that is easily accessible and understandable for decision makers. It is essential that vegetation information in the planning of management programs should be accurate and scientific in terms of floristic detail and actual plant community distribution (Cilliers & Bredenkamp, 1998).

The concept of nature in cities is relatively new in South Africa although several studies of urban nature conservation strategies were adopted by cities in South Africa (Cilliers *et al.*, 2004; Roberts, 1993). It could be useful for Spatial planning to have scientific results of natural urban open spaces to manage and plan the environment in a diverse environment such as Mbombela.

1.4 Planning and Biotope mapping

A biotope is any demarcated area in which animals and plants can live within different land-use classes (Löfvenhaft *et al.*, 2002). Biotope mapping focuses on methods of site survey and is based on field data of vegetation and other biota that is mapped over different land uses (Löfvenhaft *et al.*, 2002). Sukopp and Weiler (1988) stated that biotope mapping focused on floristic and phytosociological features because it is relatively easy to compare plant studies (Sukopp and Weiler, 1988). Biotope mapping was initially limited to natural landscapes and then focussed primarily on habitats for rare and endangered species Kaule (quoted by Cilliers *et al.*, 2004). Biotope mapping developed towards the protection and establishment of nature in cities. This may serve as a basis for the direct contact between urban dwellers and the natural elements (Sukopp *et al.*, 1980; Starfinger & Sukopp, 1994). According to Löfvenhaft *et al.* (2002), the maintenance of flora and fauna as well as the function of the ecosystem is dependent on spatial planning with consideration of how land use changes will influence the biotope structure of urban open areas.

Nature conservation projects within urban areas in Europe became famous as urban biotope mapping, but mainly focussed on floristic and phytosociological features (Starfinger & Sukopp, 1994; Müller, 1997). Urban biotope mapping was first done in Germany during the 1980s and

was developed to investigate which habitats in urban areas are important for nature conservation (Müller, 1997). Sukopp and Weiler (1988) distinguish between two methods of biotope mapping, selective and comprehension biotope mapping. Selective biotope mapping is the surveying of certain urban biotopes which are deemed worthy of protection, while comprehensive biotope mapping is an inventory of all biotopes found in urban areas. The method has since been developed and is used in many cities worldwide for urban planning (Löfvenhaft *et al.*, 2002; Müller, 1997). One of the most comprehensive vegetation surveys in urban areas was done in Greater London, but was not based on biotope mapping (Smith *et al.*, 2006). Other countries such as Japan (Müller, 1997), Sweden (Löfvenhaft *et al.*, 2002), New Zealand (Freeman & Buck, 2003) and South Africa (Cilliers *et. al.*, 2004; Roberts, 1993) have completed similar projects.

According to Löfvenhaft *et al.* (2002), biotope mapping has been used for urban planning for the first time in Germany. Löfvenhaft *et al.* (2002) suggested that, as a conceptual basis for describing and maintaining a continuity and functionality of biotopes and ecosystems, spatial aspects of biodiversity have to be included in planning. The main object of biotope studies has to be the mapping of biotopes as well as the communication of the information in a way that the different parties involved in urban and regional planning can understand and apply it. The use of biotope mapping in planning of South African urban areas is quite rare with some examples from the North West Province (Abendroth, 2004; Cilliers *et al.*, 2004; Rost 2002; Rothig, 2002).

Mbombela Local Municipality compiled documents, such as the State of Environment Report (SoER) (Naidoo *et* al., 2003), the Environmental Management Framework (EMF) (Strategic Environmental Focus, 2006), the Crocodile River Greenbelt Initiative Policy (Anon, 2004) and the Draft Open space bylaw (Anon, 2005) to improve the environment within the boundaries of Mbombela. The SoER and the EMF were investigations on a broad scale using satellite images as well as provincial data received from Mpumalanga Parks Board. The information of the SoER and the EMF was used to quantify and qualify the state of the environment. MLM residential areas have sensitive natural open areas such as rivers and streams and the EMF classifies the natural open spaces in residential areas as of low importance. These documents will be discussed in Chapter 7. Current spatial planning of the specific study areas (Planning Area A and H) will be discussed in Chapter 8 and spatially visualized in Figure 8.3 and 8.8. Previous spatial planning has been done without any biotope mapping studies. Directives of the Spatial Development Framework (SDF) (Laduma, 2006) to protect the environment were ignored for example the wetlands in Planning Precinct H3 and H7. Development has taken place in spite of the directives issued. The current study did surveys on natural open spaces in residential areas on the same scale as town planning. The environmental policies and spatial

planning were used together with this current study's results for the final recommendations to protect the remaining natural open spaces and will be discussed in Chapter 9.

1.5. Aims of this study

This study focused on biotope mapping within Mbombela and concentrated on the way in which urban monitoring procedures may be designed on a local level to provide information on biodiversity and certain important ecological processes. This information could aid in physical planning and will highlight certain aspects essential for urban planning processes. Taking the above into account, the general aims of this study can be summarised as follows:

- To ecologically analyse the urbanisation processes for scientific reasons and for successful planning and management of urban open spaces,
- To follow an approach to deal with changes in natural open spaces, influenced by anthropogenic influences, and
- To ensure that biodiversity and ecological aspects are sufficiently included in the planning of specific urban open spaces in the Mbombela Local Municipality.

1.6 Objectives

The specific objectives of this study were to:

- classify the vegetation as a basis for biotope mapping,
- do a survey on bird species in the plant communities and biotopes,
- determine carbon storage of trees in the plant communities and biotopes,
- use a subjective method of evaluation of different ecological criteria to compare the worthiness for protection of the different plant communities and biotopes,
- map all biotopes using GIS technology, and to
- give management recommendations to the Municipality of the different precincts in each studied planning area.

1.7 Dissertation layout

A review of literature on biotope mapping, urban ecology and urban planning is discussed in Chapter 1. Chapter 1 also includes the aim and objectives of the study.

An overview of the study area is given in Chapter 2, as well as a discussion of the population growth in the different Planning Areas within the Mbombela Local municipality. Chapter 2 further focuses on the geology, topography, climate conditions, vegetations, birds, other biota, conservation areas and the environmental pressures in the Mbombela Municipal area.

In Chapter 3, a description of the methodology that was implemented in the execution of this study is given. More detail on the site selection, vegetation description, bird survey, the

evaluation for carbon storage and biotopes worthy of protection as well as the biotope mapping is discussed.

In Chapter 4, the classification and description of the vegetation in Hazyview (Planning Area A) and Nelspruit (Planning Area H) are discussed. Chapter 5 is a discussion on the results of the bird survey and the carbon storage value of trees in the selected sampling plots.

An evaluation of the different biotopes worthy of protection and the biotope mapping is discussed in Chapter 6.

Environmental policies of the Mbombela Local municipality are summarized and discussed in Chapter 7. General information, the history, a discussion of the Spatial Development Framework (SDF) and the Land use Management Systems (LUMS) of Mbombela Local Municipality are discussed in Chapter 8.

Recommendations with regard to the management of open spaces with high conservation value are discussed in Chapter 9. The recommendations take the different planning and environmental policies of Mbombela into consideration.

Finally, Chapter 10 gives a brief summary of the study and concludes the thesis with an overview of, and remarks concerning the study as a whole.

1.8 Definitions

Biotope / habitat

A biotope is an area in which species/populations/organisms can survive and reproduce. A habitat can be defined as a mosaic of biotopes, or a landscape that includes all the different types of biotopes needed during the whole life cycle of an organism, that includes corridors and any other green open spaces (Löfvenhaft *et al.,* 2002).

Declared invader is a category 2 or 3 weed according to the Conservation of Agricultural Resources Act (43/1983) which is allowed only in demarcated areas under controlled conditions and outside demarcated areas must be controlled or eradicated where possible. It is prohibited within 30m of the 1:50 year flood line of watercourses or wetlands unless authorisation obtained from relevant Departments (Henderson, 2001)

Declared weed is a category 1 weed according to the Conservation of Agricultural Resources Act (43/1983) which is prohibited on any land or water surface in South Africa and must be controlled ore eradicated where possible (Henderson, 2001).

Exotic plants are not indigenous or native and are introduced plants (Schmidt *et al.,* 2002).

Indigenous (native) species are those which evolved in the area or which arrived there by one means or another before the beginning of the Neolithic period, or which arrived there since that time by a method entirely independent of human activity (Henderson, 2001).

Introduced (alien, exotic, weed, adventives) species are those which reached the area as a consequence of the activities of man or of his domestic animals (Henderson, 2001)

Invasive (naturalized, invader) species are aliens whose distribution and/or abundance are increasing regardless of their habitat (Henderson, 2001).

Natural areas

Ecosystems which persist primarily because of natural processes, plant establishment, water availability, nutrient cycling and plant-animal interactions and had minimal human manipulations (McDonnell, 1997).

Public open space

According to the Mbombela draft Open space bylaw (Anon, 2005), a public open space is any land which:

a) is owned by an organ of State, or

b) over which an organ of State has certain real rights arising from the filing in the Deeds Office or other registration office of a general plan of a township, agricultural holding or other division of land, or any alteration to or amendment of such land approved by the Surveyor-General, on which is marked the land to which the public has a common right of use; and

c) is controlled and managed by the council; and

d) is either

   i) set aside in terms of any law, zoning scheme or spatial plan for the purpose of public infrastructure or agriculture; or

   ii) predominantly undeveloped and open and has not yet been set aside for a particular purpose in terms of any law, zoning scheme or spatial plan.

Rural areas

Rural areas are areas with less than 1 person per ha (Laduma, 2006).

Riparian habitat

According to the National Water Act (NWA) (73/1998), a riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure from those of adjacent land areas.

Urban agricultural public open space:

According to the Mbombela draft Open space bylaw (Anon, 2005) and Venter, 1995, an agricultural public open space is managed by, or on behalf of the Council for urban agricultural purposes.

Urban areas

Urban areas are considered as areas with 6.2 persons / ha (Laduma, 2006)

Watercourse

Watercourse, according to the NWA (73/1998), means a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which, water flows and any collection of water which the Minister of Water Affairs and Forestry, by notice in the Gazette, declares to be a watercourse and a reference to a watercourse includes, where relevant, its bed and banks.

CHAPTER 2



Study Area

CHAPTER 2

STUDY AREA

2.1 Introduction

Nelspruit is the capital city of Mpumalanga Province and forms part of the Mbombela Local municipality (MLM) that consists of Nelspruit, White River and Hazyview, which were merged during 2000. Mbombela lies in the eastern part of the Mpumalanga Province, between 25° 30'S and 31°0'E. According to the State of Environment Report (SoER) (Naidoo *et al.*, 2003) it comprises an area of approximately 333071.72 ha (Figure 2.1).

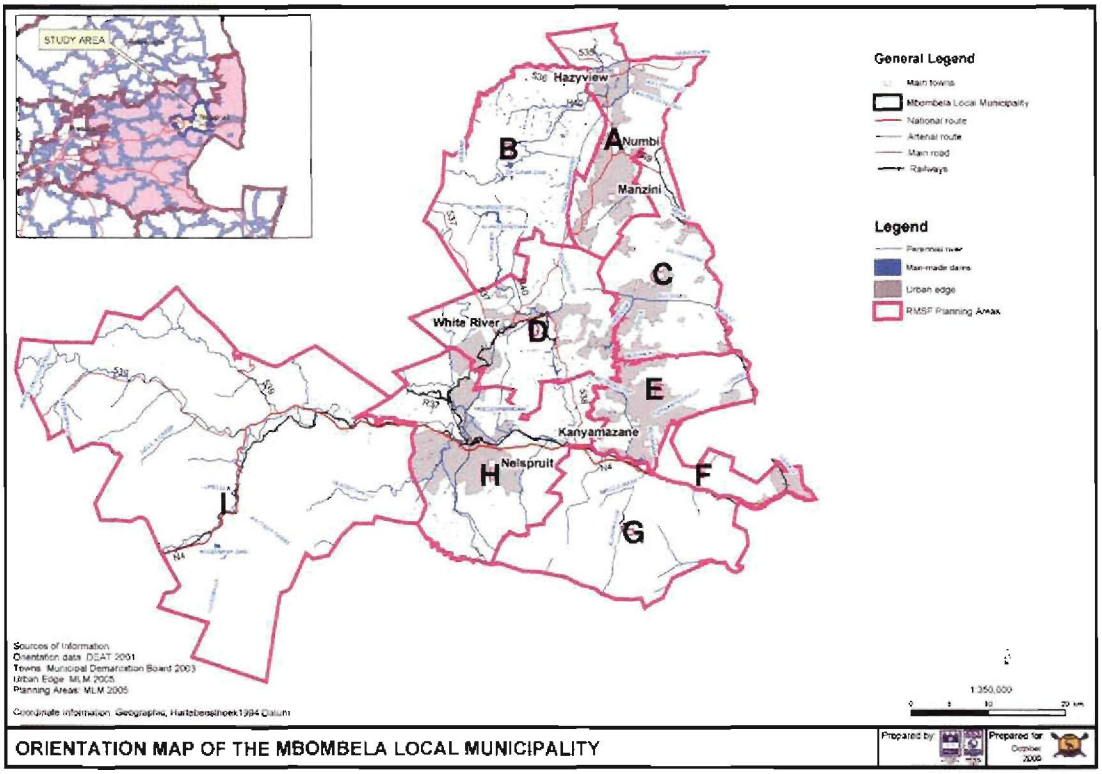


Figure 2.1: Location of Mbombela in the Mpumalanga Province (Strategic Environmental Focus, 2006)

According to Venter (1995), the average population growth in Nelspruit was 4.6% for 1990 to 1995 and has increased to approximately 6% since the town obtained capital status. The Mbombela SDF (Laduma, 2006) indicates that the total population in MLM is 650 966 for 2006 (Table 2.1). Approximately 75% of the population lives in rural areas with the majority of these people living in tribal settlements.

This rapid increase of human population in urban areas had a marked effect on the environment. To guide authorities with the increasing people in urban areas, Mbombela was

divided into nine Planning Areas and these divisions were based on population densities (Laduma, 2006). The division of Mbombela will be discussed in Chapter 8.

The environmental characteristics and description of Mbombela and the pressures on the environment are described in this chapter. The descriptions include Mbombela as a whole and the two selected study areas, Planning Area A (Hazyview) and Planning Area H (Nelspruit). The procedures for site selection will be discussed in Chapter 3, as well as the methods for evaluation of the environment for the two selected planning areas.

2.2 Population growth

The management of future planning for new residential developments depend on the population growth of a certain area. Mbombela's Spatial Development Framework (SDF) (Laduma, 2006) included two projections of the population estimation for the planning areas over a 15-year period (2006-2021) but excluded the possible effect of HIV-Aids. The second population estimation was for the same period of time, but included the possible effect of HIV/Aids on the population escalation. An average annual growth of 3.6% for 2004-2009, 2.6% for 2006-2011 and 1.9% for the period 2014-2019 were estimated (See Table 2.1).

Table: 2.1. Population estimation of the different Planning Areas in Mbombela Local Municipality, 2006 – 2021 (Laduma, 2006)

Planning Area	2006		2011		2021	
	Without AIDS	With AIDS	Without AIDS	With AIDS	Without AIDS	With AIDS
A	147 027	142 491	171 299	160 350	211 472	179 584
B	9323	9269	9738	9569	10 340	9550
C	92 753	89 892	108 066	101 158	133 409	113 293
D	58 625	58 323	68 303	67 211	84 321	78 199
E	215 774	209 118	251 395	235 326	310 352	263 555
F	55 250	53 442	60 744	56 682	69 210	58 485
G	2433	2349	2529	2352	2667	2243
H	58 736	58 457	73 738	72 626	100 974	93 898
I	11 045	10 662	11 480	10 678	12 106	10 180
Total	**650 966**	**634 003**	**757 291**	**715 953**	**911 199**	**785 333**

This escalation provides the hierarchy of residential districts, communities and neighbourhoods. According to the Mbombela SDF (Laduma, 2006), the population projection is also used to determine the demand for schools, social services and houses.

2.3 Geology and soils

The underlying geology is granite or gneiss in Planning Area A (Hazyview) and Planning Area H (Nelspruit). Planning Area A (Hazyview) has dolerite intrusions and areas covered by gabbro (Low & Rebelo, 1996). The dolerite soils are chemically richer and support a great variety and profusion of plant species. The soils are mainly granites and are generally shallow and sandy.

Planning Area A (Hazyview) has sandy soils in the uplands and clayey soils with high sodium content in the valleys. Planning Area H (Nelspruit) has deep sandy to sand loam soils in the uplands, to clayey soils with a strong structure in the valleys. Most of the Nelspruit soils are heavy and derived from volcanic rocks (Figure 2.2).

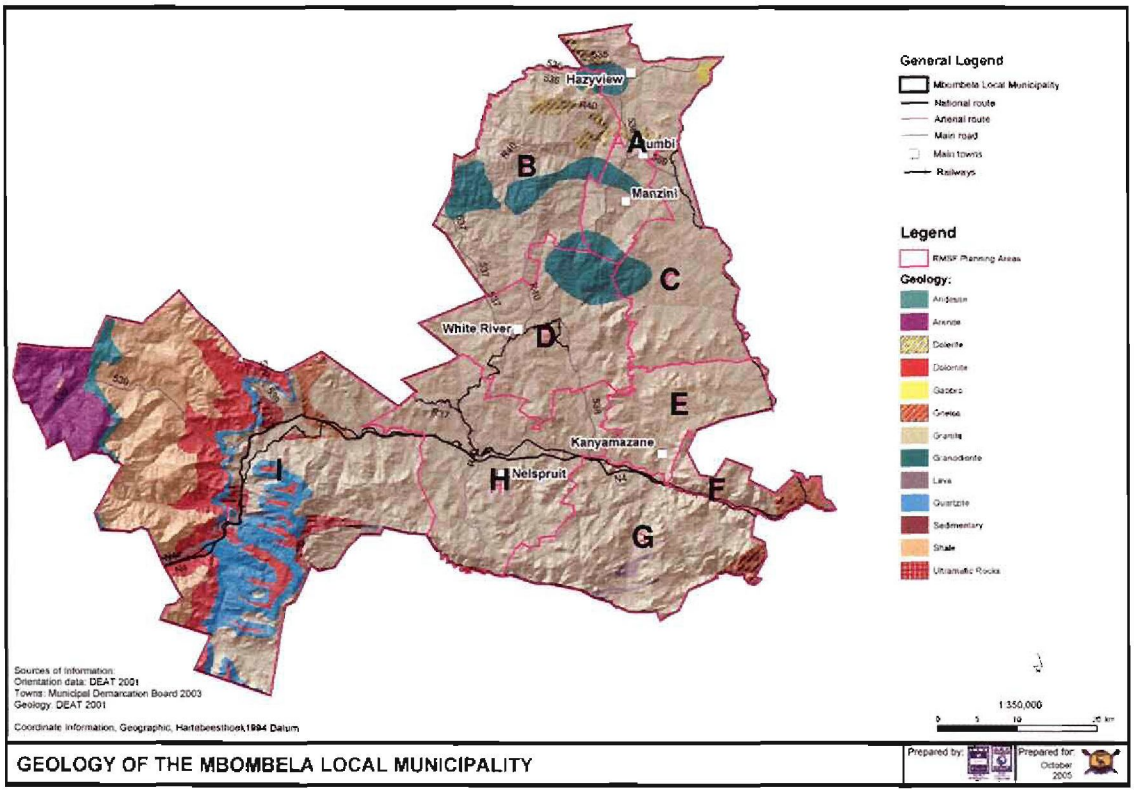


Figure 2.2: Geology of Mbombela (Strategic Environmental Focus, 2006)

2.4 Topography and Rivers

The topography of Mbombela varies from large granite rocky outcrops, hills and ridges, to woody valleys, rivers, streams and drainage lines. The altitude varies between 300 meters above sea level (masl) in the Lowveld and 1900 masl in the Highveld areas (Naidoo *et al,* 2003). The altitude in the specific studied areas varies between 350 – 500 masl in Planning Area A (Hazyview) and 550 – 800 masl in Planning Area H (Nelspruit) (Low & Rebelo, 1996) (Figure 2.3).

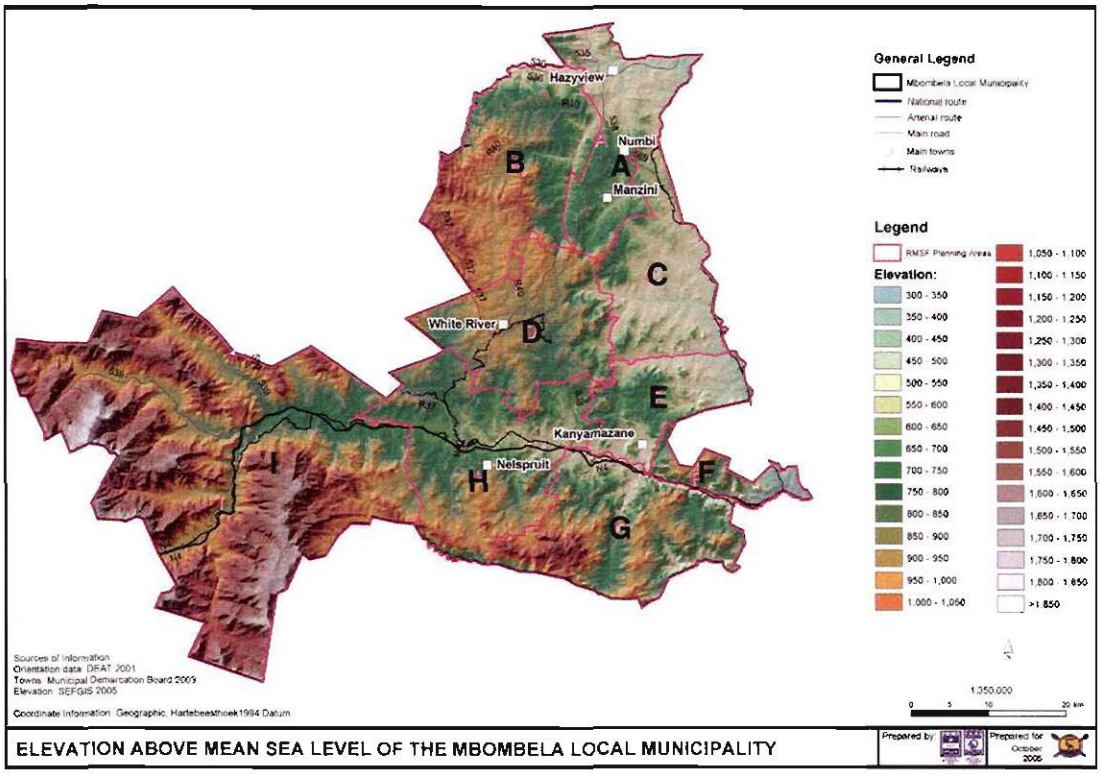


Figure 2.3: Altitude range within Mbombela (Strategic Environmental Focus, 2006)

There are 4 major river systems in Mbombela: Crocodile River, Elands River, North Sand River and the Sabie River, with the North Sand River in Planning Area A and the Crocodile River in Planning Area H (Figure 2.4). Rivers in Mbombela are natural with few modifications such as flow obstructions including weirs and dams, roads, bridges. According to the Naidoo *et al.* (2003), all river systems within urban areas are considered as important for conservation areas. Other water bodies are the Da Gama Dam, Nsikazana Dam, Ngodwana Dam, Friendenheim Dam, Primkop Dam, Longmere Dam and Klipkoppie Dam (Naidoo *et al.*, 2003).

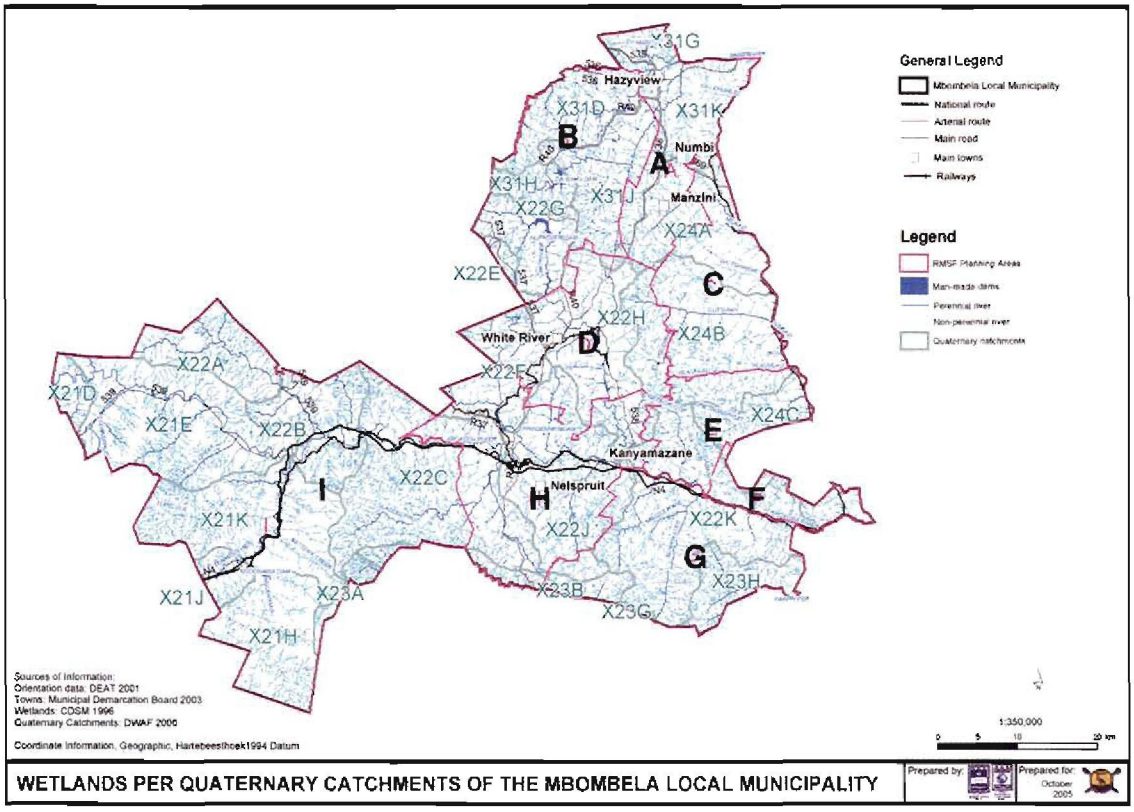


Figure 2.4: Rivers in Mbombela (Strategic Environmental Focus, 2006)

2.5 Climate conditions

Mbombela lies in the sub-tropical Lowveld with hot and humid summers from October to April with the bulk rainfall occurring during this period. The average rainfall is 790mm. Warm and dry winters from May to September are frost-free and temperatures rarely fall below freezing point. The mean maximum temperature is between 28 and 30°C. The mean minimum temperature is between 5 and 8^0C (Strategic Environmental Focus, 2006).

2.6 Vegetation

Mpumalanga has a wide diversity of vegetation which varies from open to dense bushveld (Onderstall, 1984). According to Schmidt *et al.* (2002), four major vegetation elements are dominant in Mpumalanga, namely the Highveld grasslands, escarpment grassland-forest mosaic, eastern Lowveld savannas and north-western bushveld savannas. These are represented in three distinct biomes: forest, savanna and grassland (Schmidt *et al.*, 2002).

Acocks (1988) described the Nelspruit (Planning Area H) veld types as Lowveld Sour Bushveld (9) and the Hazyview (Planning Area A) veld type as Lowveld (10). The veld type descriptions are more appropriate for agriculture, because it was designed by looking at the resource usages. Low and Rebelo (1996) divided vegetation types according to units with similar

vegetation structure, sharing important plant species and those that have similar ecological processes. According to Low and Rebelo (1996) Mpumalanga has 3 biomes, namely Forest Biome, Grassland biome and Savanna Biome and 16 Vegetation types. Hazyview (Planning Area A) and Nelspruit (Planning Area H) fall within the Sour Lowveld Bushveld (21) vegetation type.

Mucina and Rutherford (2006) described the vegetation in Planning Area A (Hazyview) as Legogote Sour Bushveld (SVI 9) and Pretoriuskop Sour Bushveld (SVI 10). Planning Area H (Nelspruit) vegetation is described as Legogote Sour Bushveld (SVI 9), Pretoriuskop Sour Bushveld (SVI 10) and Malalane Mountain Bushveld (SVI 11) (Mucina & Rutherford, 2006).

The vegetation and landscape features of the Legogote Sour Bushveld (SVI 9) are described by Mucina and Rutherford (2006) as gently to moderately sloping upper pediment slopes with dense woodland that include medium to large shrubs, dominated by *Parinari curatellifolia* and *Bauhinia galpinii* with *Hyperthelia dissoluta* and *Panicum maximum* in the undergrowth. Short thicket dominated by *Acacia ataxacantha* occurs on less rocky sites. Exposed granite outcrops (Figure 2.5) have low vegetation cover typically with *Englerophytum magalismontanum*, *Aloe petricola* and *Myrothamnus flabellifolia*.

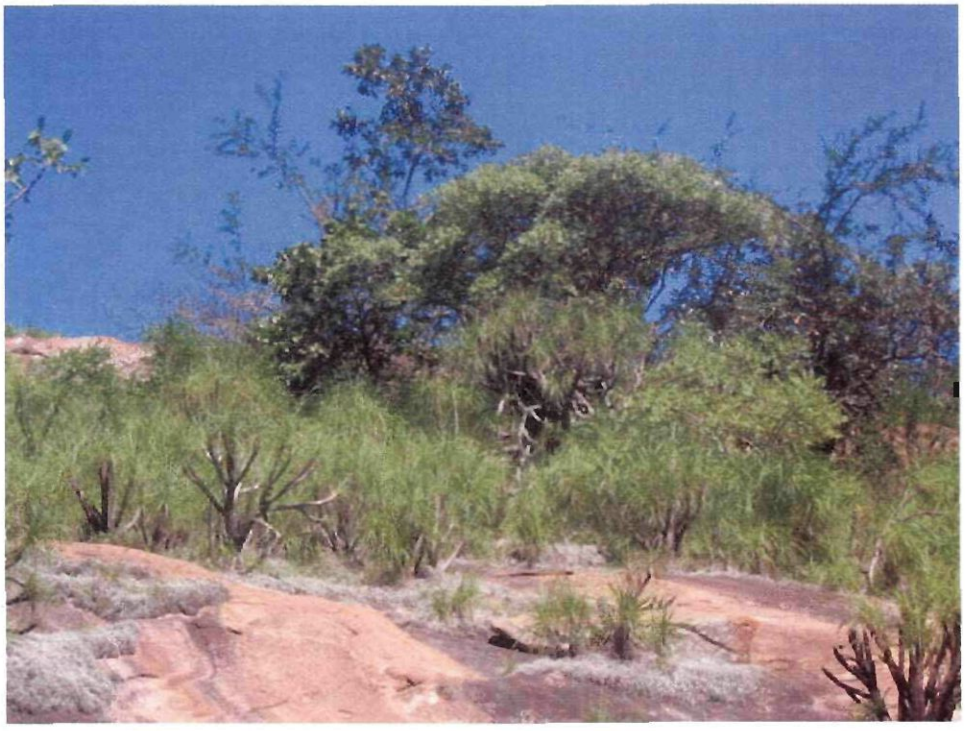


Figure 2.5: Exposed granite outcrops in Nelspruit.

The Pretoriuskop Sour bushveld (SVI 10) vegetation and landscape features are described by Mucina and Rutherford (2006) as uplands with a tree savanna dominated by *Terminalia sericea*

and *Dichrostachys cinerea* with relatively few low shrubs and dense grassy layers, dominated by sour grasses such as *Hyperthelia dissoluta, Elionurus muticus* and *Hyparrhenia hirta*. Grass composition changes somewhat on the mid slopes, and in the narrow bottomlands the dominant species include *Acacia nilotica, A. gerrardii* and *A. tortillis, Digitaria eriantha, Eragrostis superba* and *Aristida congesta* (Figure 2.6). This vegetation is related to the Legogote Sour Bushveld (SVI 9), but is drier.



Figure 2.6: Grasslands dominated by *Digitaria eriantha* and *Eragrostis superba* with *Acacia* spp

Mucina and Rutherford (2006) described the vegetation and landscape features of Malelane Mountain Bushveld (SVI 11) as an open savanna on mountains and higher-lying slopes with an open to dense, short mountain bushveld on rocky outcrops (Figure 2.7 and 2.8) and lower-lying areas. Altitude and aspects are important in determining species composition in this mountainous terrain. According to Mucina and Rutherford (2006), this mountainous unit is similar to the Legogote Sour Bushveld (SVI 9), but has a wetter and cooler climate. Two broad groups of plant communities are recognised, namely the high-lying open savannas and the low-lying closed savannas. The transition between these two community complexes is at an altitude of 700m.



Figure 2.7: Shrubby bushes on rocky outcrops in Nelspruit.



Figure 2.8: Rocky outcrops with *Xerophyta retinervis*, grasses and trees in Nelspruit.

2.6.1 Alien vegetation

Some of the areas in Mbombela are severely infested by alien invasive species. According to Naidoo *et al.* (2003), species that cause serious problems are *Euclyptus* spp, *Pine* spp, *Psidium gujava, Lantana camara* and *Melia azedarach.* Other alien species with fewer effects are *Acacia mearnsii, Rubus* spp, *Tagetes minuta, Solanum mauritianum* (Figure 2.9), *Ricinis communis, Opuntia stricta, Argemone mexicana, Sesbania punicea* and *Acacia dealbata.*



Figure 2.9: Alien vegetation, *Tagetes minuta* and *Solanum mauritianum* in Nelspruit

2.6.2 Sensitive habitats and plants

The protection of sensitive habitats is essential for biodiversity protection because these habitats tend to contain a wide range of ecosystem processes and a high diversity of plants and animals. Three habitat units are found within Mbombela, namely Natural Grasslands, Natural Forest and Wetlands. Natural Grasslands is the largest unit (44.5%), followed by Natural Forest (7.5%) and wetlands (0.3%). Riparian zones are also of ecological importance and a sensitive habitat (Naidoo *et al.*, 2003).

Table 2.2: Red Data plant species that are likely to occur within Mbombela, according to Naidoo *et al.* (2003).

Status	Species
Critically endangered	*Adenium swazicum, Aloe simii, Dioscorea* sp. nov., *Encephalartos laevifolius, Haworthia limifolia* var. *limifolia, Platycoryne mediocris, Protea roupelliae, Siphonochilus aethiopicus*
Endangered	*Aloe albida, Bowiea volubilis, Erica revoluta, Leucospermum gerrardii, Warburgia salutaris, Watsonia wilmsii*

Distributions were based on modelled distributions.

2.7 Birds

Mbombela has a total of 21 Red Data bird species of which 14 are considered Vulnerable and 3 are considered Globally Threatened (Table 2.2). The Blue Swallow that occurs in the Kaapsehoop area has between 8-12 breeding pairs and is considered to be on the verge of extinction. Indian Myna numbers have increased and this is the only alien bird species that is a problem within Mbombela. No data of the Indian mynas are available but it seems that the birds are restricted to urban areas in Nelspruit (Naidoo *et al.*, 2003).

Table 2.3: Red Data bird species that are likely to occur within Mbombela according to SoER (2003).

Status	Species
Critically endangered	Blue swallow (Globally vulnerable); Rudd's Lark; Saddle bill Stork.
Endangered	Black-rumped Buttonquail; Lappet-faced Vulture; White-headed Vulture
Vulnerable	African Marsh Harrier; Bald Ibis (Globally threatened); Bateleur; Blue Crane; Cape Vulture (Globally threatened); Crowned Crane; Grass Owl; Ground Hornbill; Martial Eagle; Peregrine Falcon; Stanley's Bustard; Striped Flufftail; White-bellied Korhaan; Yellow-breasted pipit.
Near Threatened	Pink-throated Twinspot

2.8 Other biota

Red Data species are considered sensitive to environmental change and their numbers serve as indicators of environmental conditions. The information presented is based on modelled distributions obtained from the Mpumalanga Parks Board's Biobase (Emery *et al.*, 2002 in Naidoo *et al.*, 2003). A total of 114 terrestrial Red Data species are expected to occur within Mbombela, of which 12 are considered critically endangered, 19 are considered endangered and 48 are considered Vulnerable (Naidoo *et al.*, 2003).

2.9 Conservation areas

An estimated 79 600 ha (21%) of Mbombela receives formal conservation protection, including conservancies (Table 2.4). The largest protected area is the Mthethomusha Nature Reserve (8 137 ha) on the border of the Kruger National Park. The plateau at Kaapsehoop is an important area for conservation of plants, particular herbaceous grassland species. This is the third largest breeding population of Blue Swallows in South Africa (Naidoo *et al.*, 2003). One of the Nature Reserves in residential areas is the Nelspruit Private Nature Reserve (Figure 2.10)

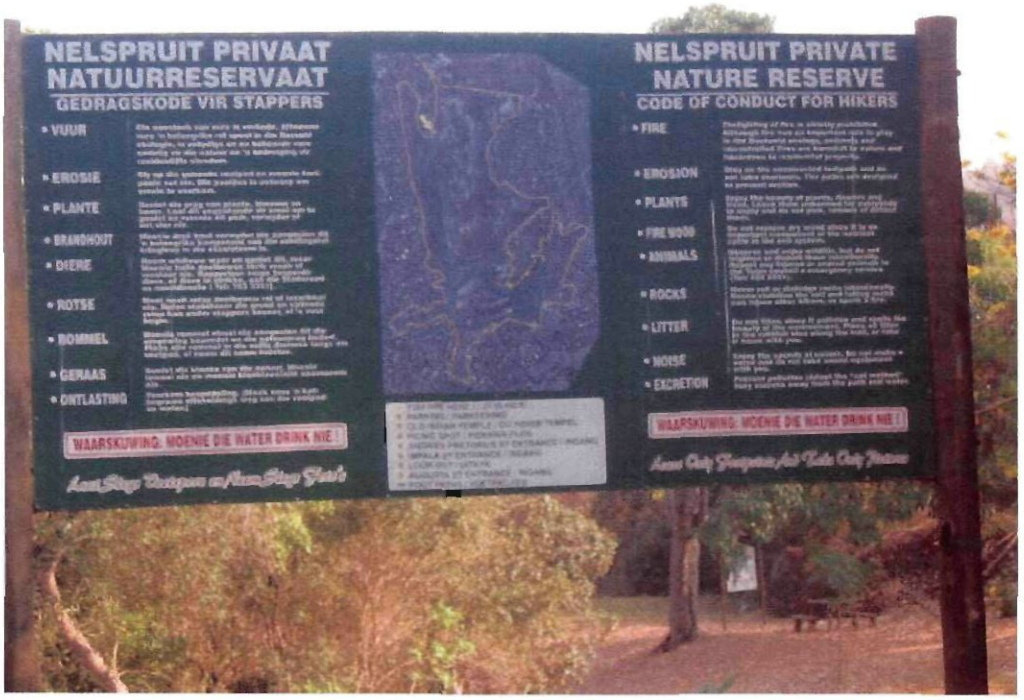


Figure 2.10: The entrance of Nelspruit Private Nature Reserve

Table 2.4: Protected areas in Mbombela according to Naidoo *et al.* (2003).

Name	Category	Size (ha)
Crocodile Gorge Conservancy	Conservancy	24 990
Kaapsehoop	Conservancy & Natural Heritage site	17 710
Mount Carmel	Conservancy	6 914
Nelspruit	Conservancy	159
Kudus Hoek	Natural Heritage Site	2 020
Mbesan	Natural Heritage Site	1 882
Blue Swallow	Natural Heritage Site	470
Barberton Nature Reserve	Nature Reserve	1 330
HL Hall Nature Reserve	Natural Heritage Site	(100)
Inhlaba	Natural Heritage Site	(50)
Mbobo Mkhulu Cave	Natural Heritage Site	843
Poplar Creek	Natural Heritage Site	2 875
Spinnekop se nes	Natural Heritage Site	(20)
Sudwala Caves/Rainforest	Natural Heritage Site	146
Nelspruit Botanical Gardens	Botanical Gardens	(200)
Lomshiyo	Cattle-Game Project	(1 000)
Uitkyk	Private Nature Reserve	(500)
Rocky's Drift	Private Nature Reserve	(200)
Wonderkloof	Nature Reserve	(200)
Mthethomusha	Nature Reserve	8 137
Etzerstroom	Nature Reserve	(200)
Starvation Creek	Nature reserve	521
Nelspruit	Nature Reserve	138
Daga Structure Mid Late Stone Age	Archaeology Site	
Farm: Karino Late Stone Age	Archaeology Site	
Farm: Tipperary Late Stone Age	Archaeology Site	
Farm: Sunnyside Mid Stone Age	Archaeology Site	
Total	Protected areas (22% of Mbombela) Conservancies (15% of Mbombela)	74 350 79 600

Shaded areas are in Planning Area H

2.10 Pressures on natural areas in MLM

According to Lawson (2001), 20% of the Nelspruit municipal area had been developed for industrial, commercial and residential areas in 1980, then consisting of approximately 720ha. The population at that time was 15 940. By 2000 the developed area has increased by 60%, totalling 2 160ha of developed area. The residential population in Nelspruit had increased to 33 708 by 2001 (Lawson, 2001). According to Mbombela SDF (Laduma, 2006) the total area of

Mbombela is 333 071.7ha with a population of 650 966 in 2006 and will increased to 911 199 in 2021.

Mbombela is situated at the foothills of the Drakensberg with sensitive areas such as drainage lines, grasslands and hills and ridges (Naidoo *et al.*, 2003), on which the existing residential areas already had a negative impact (Figure 2.11 - 2.14).



Figure 2.11: Residential development within wetlands.



Figure 2.12: Garden refuse and general waste deposits within wetland areas.



Figure 2.13: Storm water management of a shopping centre in Hazyview



Figure 2.14: Burning of wetlands during winter months.

An annual population growth rate of 3.6% for the next five years was estimated for Mbombela Local Municipality (Laduma, 2006) and this could be an indication of the natural areas that will be converted to residential areas as well as an increase of gardens with alien flora in future. There is a tendency to favour exotic plants in central urban open spaces of South Africa (Roberts & Poynton, 1985), 70% of garden flowers in London are exotic (Smith *et al.*, 2006), while Godefroid (2001) indicated that there was an increase in alien plant species and a decrease in native plant species in two parks in Brussels, Belgium. Nelspruit (Planning Area H) had well-developed gardens in residential areas and large managed open spaces, while in rural residential areas such as Hazyview (Planning Area A) there are no well-developed gardens or managed open spaces. The differences in gardens and open spaces could have different impacts on the natural open spaces in the different planning areas. With bad refuse management and the disposal of garden refuse in wetlands or open spaces (Figure 2.12), these exotic garden flowers spread to the natural river systems.

Land use activities have transformed most of Mbombela, and few habitats remain in their natural or near-natural state. Remaining natural habitats have effectively become "islands", and as the size of these islands are reduced, so too are the numbers of species that they are able to support. Many species that once inhabited Mbombela are no longer found in the area, or are restrict to isolated "islands" of suitable habitat. The ecologically important "islands" include

natural forests, wetlands, riparian zones and natural grasslands, and these are critical for the continued survival of many species in the region (Naidoo *et al.*, 2003).

According to the Naidoo *et al.* (2003), the main cause of terrestrial resources degradation within Mbombela is agriculture that leads to the loss and fragmentation of natural habitats to the point where they are no longer viable for certain species. Agricultural development, in particular the planting of timber and other commercial crops, has resulted in huge tracts of breeding and foraging grassland habitat being lost (Figure 2.15 and 2.16). Soils that are cultivated with timber (mostly gum and pine) tend to be acidic because timber plantations remove acid neutralizing rations such as calcium, magnesium and potassium. Soil erosion is also a serious problem in some areas. Degradation of drainage areas and damming of wetlands resulted in the loss of suitable foraging grounds as well as roosting sites for birds (Naidoo *et al.*, 2003).

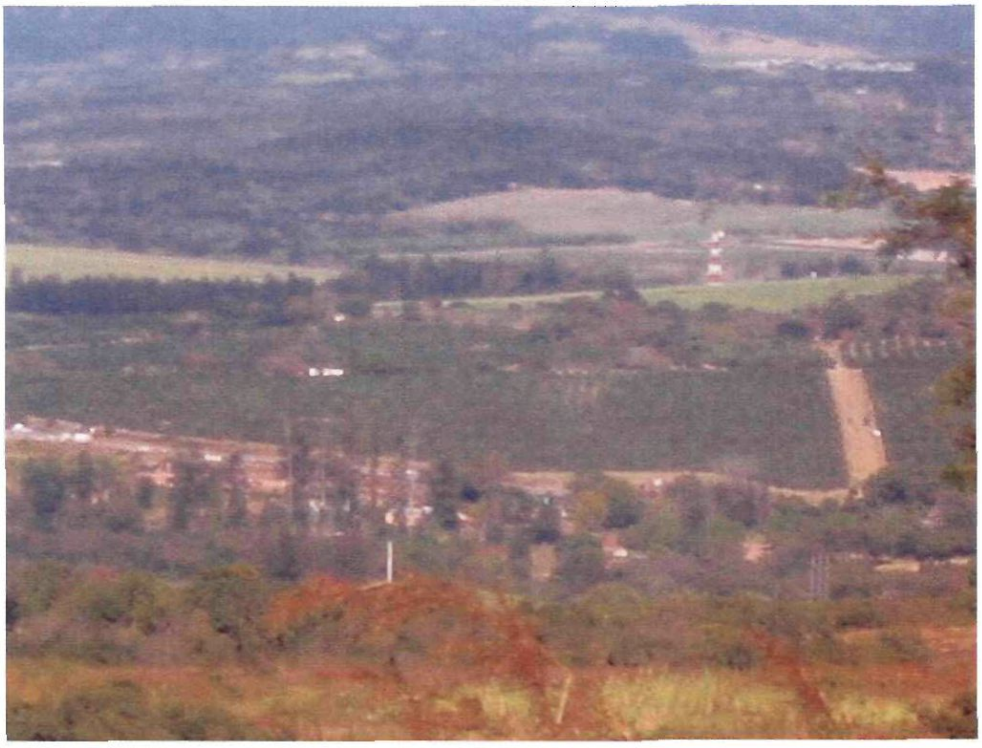


Figure 2.15: Agricultural activities close to Nelspruit



Figure 2.16: Agricultural activities in Hazyview

Destruction of the natural areas takes place daily in Mbombela. People make use of the natural vegetation for daily livelihood in rural areas. Vegetation is used for medicine, food, building of shelters and energy for food preparation and heat during the winter. Although veld fires are a natural phenomenon, the frequency of fires within Mbombela is far greater than natural burning regimes (Strategic Environmental Focus, 2006). One of the possibilities could be because of the many homeless people who stay in the wetland/drainage lines. These uncontrolled fires destroy sensitive vegetation that includes the bigger trees found in these areas (Figure 2.14). It is important to calculate the possible carbon storage value of trees in these areas to promote the conservation value of trees in urban as well as rural residential areas (discussion in Chapter 5). The demand for collector's species, such as cycads and tree ferns, put populations of some species under significant pressure. Bush encroachment from overgrazing, and poor fire management are also drivers that change terrestrial resources. This is likely to have had a major impact on vegetation structure and species composition.

Housing development and associated urban sprawling have a detrimental impact on biodiversity and water sources within Mbombela. The water sources are under pressure due to the high demand of water for human and agricultural consumption (Naidoo *et al.*, 2003). Future development can still be managed with the necessary planning actions to mitigate potential human impacts and therefore a scientific study to manage open spaces is important.

CHAPTER 3



Materials and Methods

CHAPTER 3
MATERIALS AND METHODS

3.1 Introduction

The main causes of terrestrial resources degradation within Mbombela are agricultural and urban expansion (Laduma, 2006). These expansions lead to the fragmentation of natural habitats where the remaining habitats become "islands". As the size of these "islands" is reduced, so too are the numbers of species that have been supported by these "islands (Laduma, 2006). These changes have a detrimental impact on biodiversity, but with a well-developed management program for these remaining habitats, impacts on natural areas could be mitigated. To develop a management program, baseline information of these remaining natural habitats is needed.

In order to give an overview of the status of natural open spaces of Mbombela, this current study surveyed two of the nine planning areas in the MLM. The ecological study describes the vegetation in the natural open spaces in residential areas of Planning Areas A and H as discussed in Chapter 4. Vegetation descriptions, bird data and habitat criteria in these open spaces were used as tools for evaluation of the environment as discussed in Chapter 6. Bird surveys and carbon storage, as discussed in Chapter 5, are an outcome for the evaluation of conservation importance which will be used for recommendations (Chapter 10) to manage open spaces effectively.

This chapter describes the methods used for plant surveys and vegetation description as well as for bird surveys, the interpretation of the bird data and the evaluation procedures of tree structure in the different communities and biotopes. The method for the evaluation of importance value and the biotope mapping of these areas are also discussed in this chapter.

3.2 Site selection

Within the nine subdivisions of Mbombela (Figure 8.2), Planning Area A, Hazyview – densely populated residential area (Figure 8.3) and Planning Area H, Nelspruit – urban area with larger stands in residential areas (Figure 8.8) were selected for this study.

Planning Area A was chosen as an informally planned residential area with rural villages with subsistence crop production and livestock on communal land (Figure 3.1). Tshabalala was formally planned by urban planners, while stands were informally handed out in Nyongani and Nkambeni by the Chief. This area has weak engineering systems with a high residential growth. Most of the people have a low income and cannot afford municipal services (Laduma, 2006).

This area is also densely populated with small natural open spaces between the residents (Figure 3.1 and 3.3). Future development has to be planned carefully to ensure social demands and the prevention of environmental degradation of natural open spaces.

The residents in Planning Area A make use of open spaces for daily living namely for collection of firewood, curios, building or fences and collection of plants for food and medical uses, as well as for cattle and goat grazing. Most of the wood harvesting takes place in the Nyongani, Tshabalala, Nkambeni and Numbi areas, according to Steenkamp (quoted by Naidoo *et al.*, 2003) (Figure 3.2).

Hazyview has been described by Deal (1985) as the Lower foothills (500–700 masl) with wide valley-bottoms and gentle slopes. The Lower foothills lie between the Upper foothills (700-900 masl) and the Lowveld (200-500 masl). With the initial investigation of the area, no grasslands were found in the natural open spaces of Planning Area A (Tshabalala, Nyongane and Nkambeni) and sampling was done in the valleys. Twenty-two relevé points were selected on riparian areas, valleys and hills/ridges within the residential natural open spaces (Figure 3.3).



Figure 3.1: Residential area of Nyongani with exposed granite outcrops.

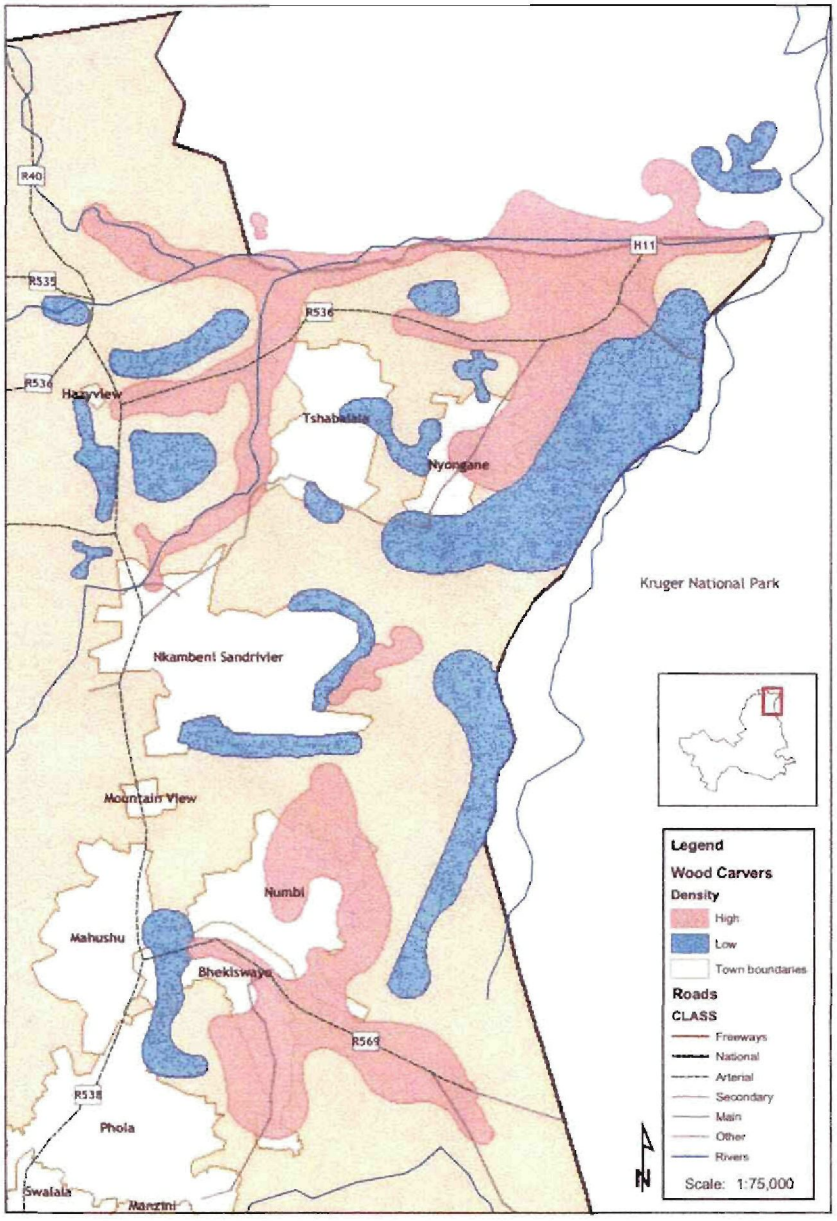


Figure 3.2: Wood harvesting areas (Naidoo *et al.*, 2003)

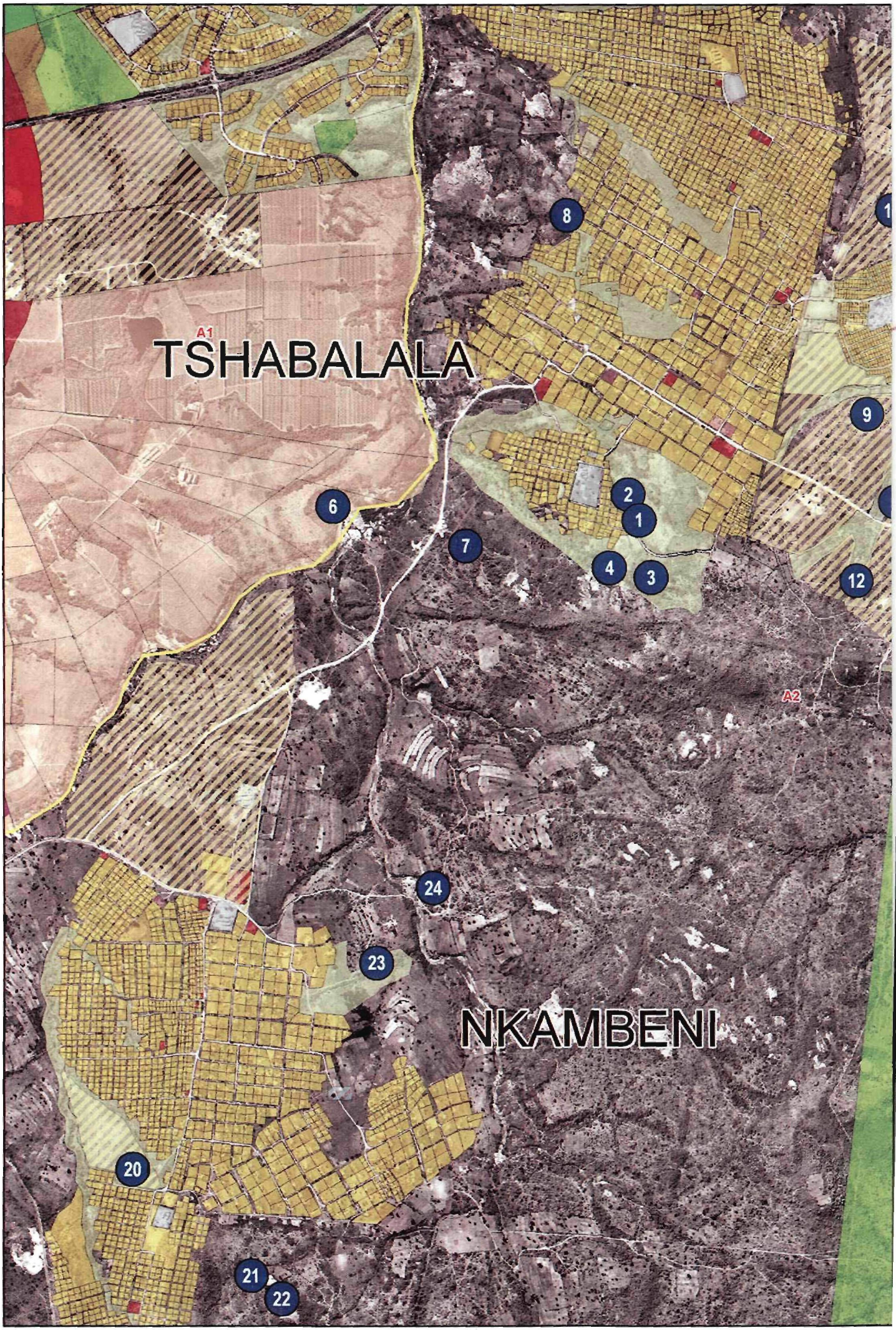
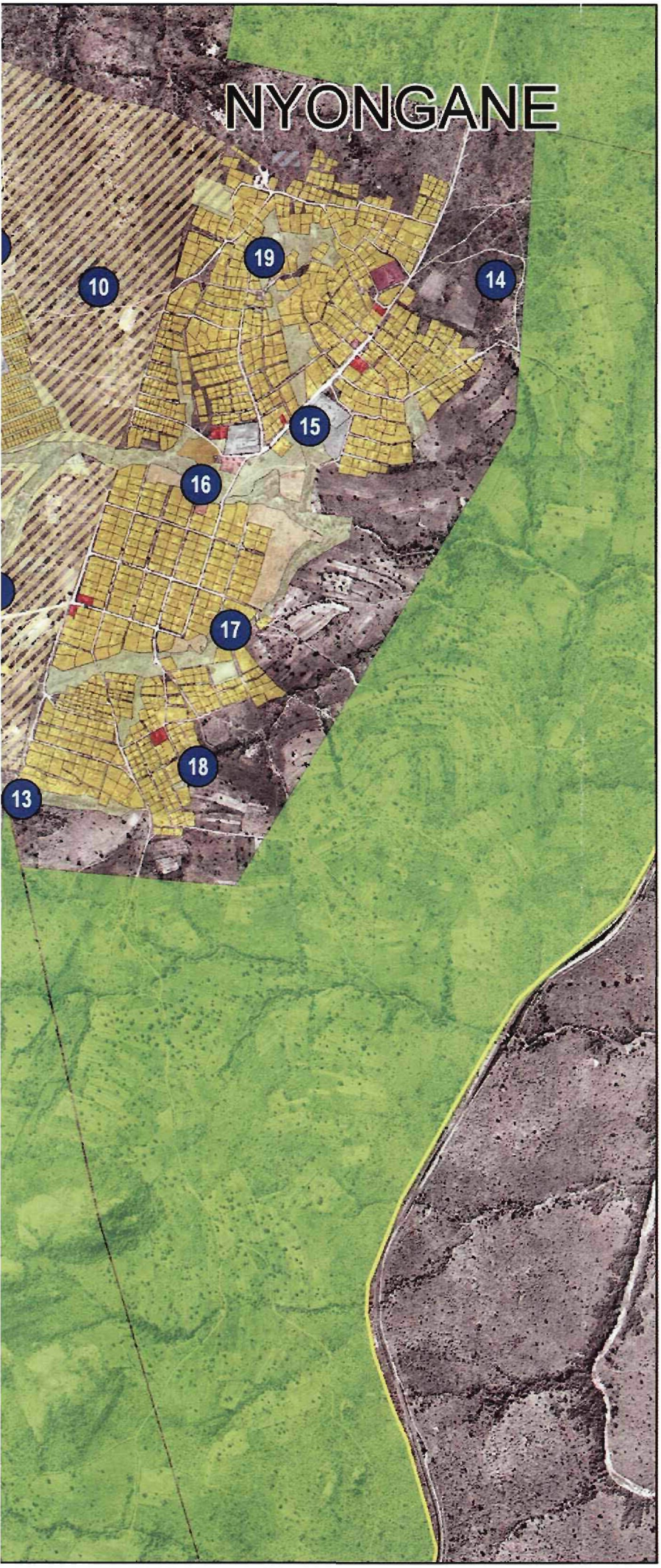


Figure 3.3: Aerial photo of Planning Area A (Hazyview) with residential areas and relevé positions

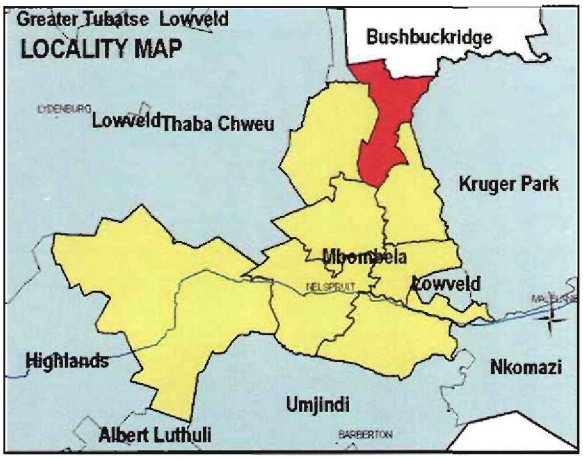


PLANNING AREA A
RELEVE POSITIONS

Legend

- SamplingPoints
- Precincts 06
- State Land
- Agriculture
- Business
- Community Facilities
- Utilities
- Entertainment
- Cemetry
- Conservation
- Tourism and Accommodation
- Open Space
- Residential
- Future Residential
- Urban Agriculture
- Education

SCALE: 1:25,000



Planning Area H was chosen as a formally planned residential area with larger stands (Figure 3.4 and 3.5). This area has a properly planned and engineered water and electricity system. Although people in this area vary from having high to low incomes and most can afford the municipal services, many homeless people looking for food and jobs stay in the open spaces close to the Central Business District (CBD). People with higher incomes normally produce more waste that has to be managed properly and they have beautiful gardens with a high biodiversity of introduced species that end up in waterways and eventually in rivers. Planning Area H has more heavy industries that could pollute natural areas than Planning Area A. Natural open spaces in Planning Area H have to be managed and monitored carefully to enhance biodiversity in urban areas of Mbombela. Twenty-eight relevé points were selected in riparian areas, grasslands and hills/ridges, indicated according to the Mbombela Naidoo *et al.* (2003) as the most sensitive natural areas in Mbombela (Figure 3.5).



Figure 3.4: Typical residential area in Nelspruit, with small commercial area on the foreground.

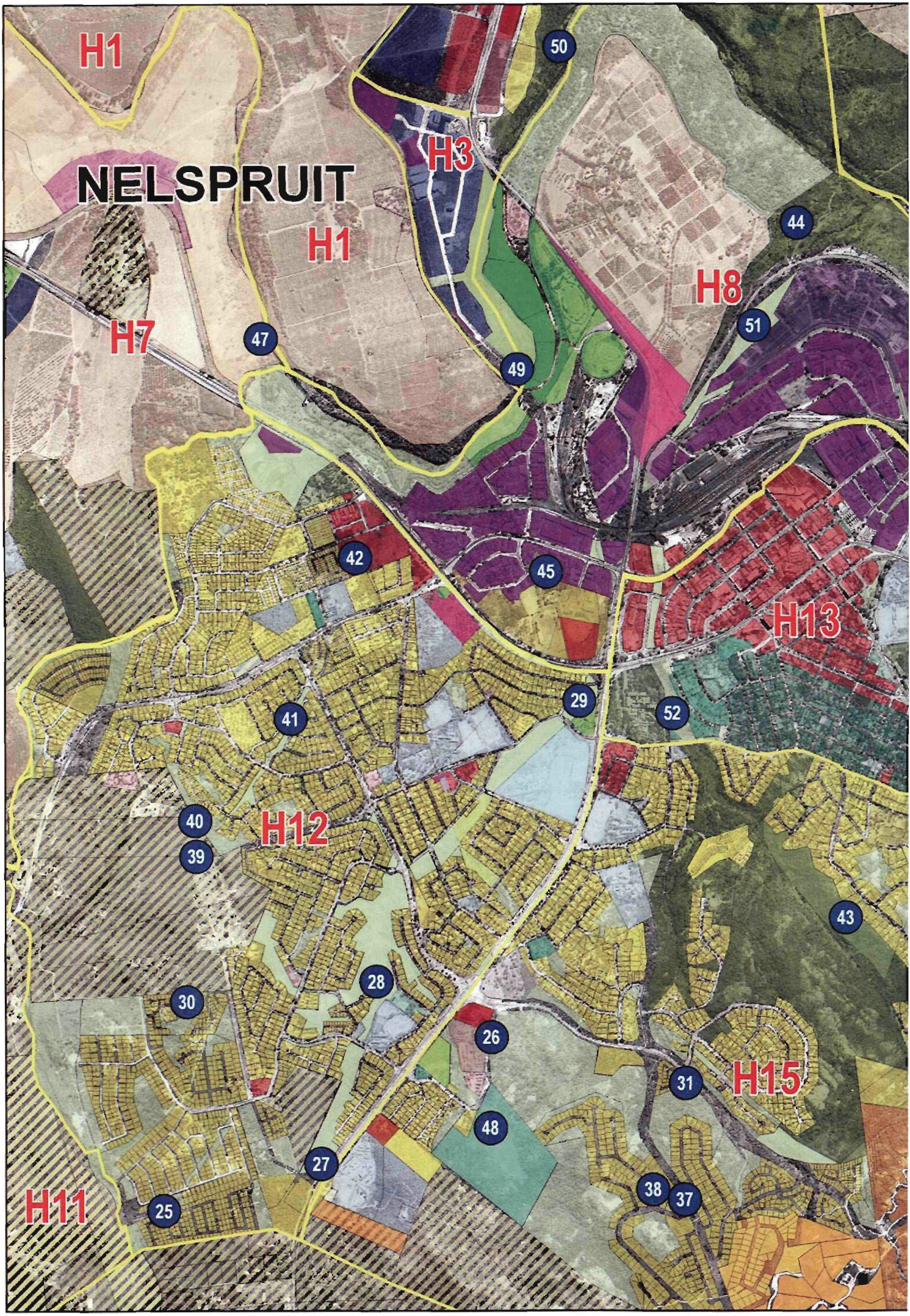
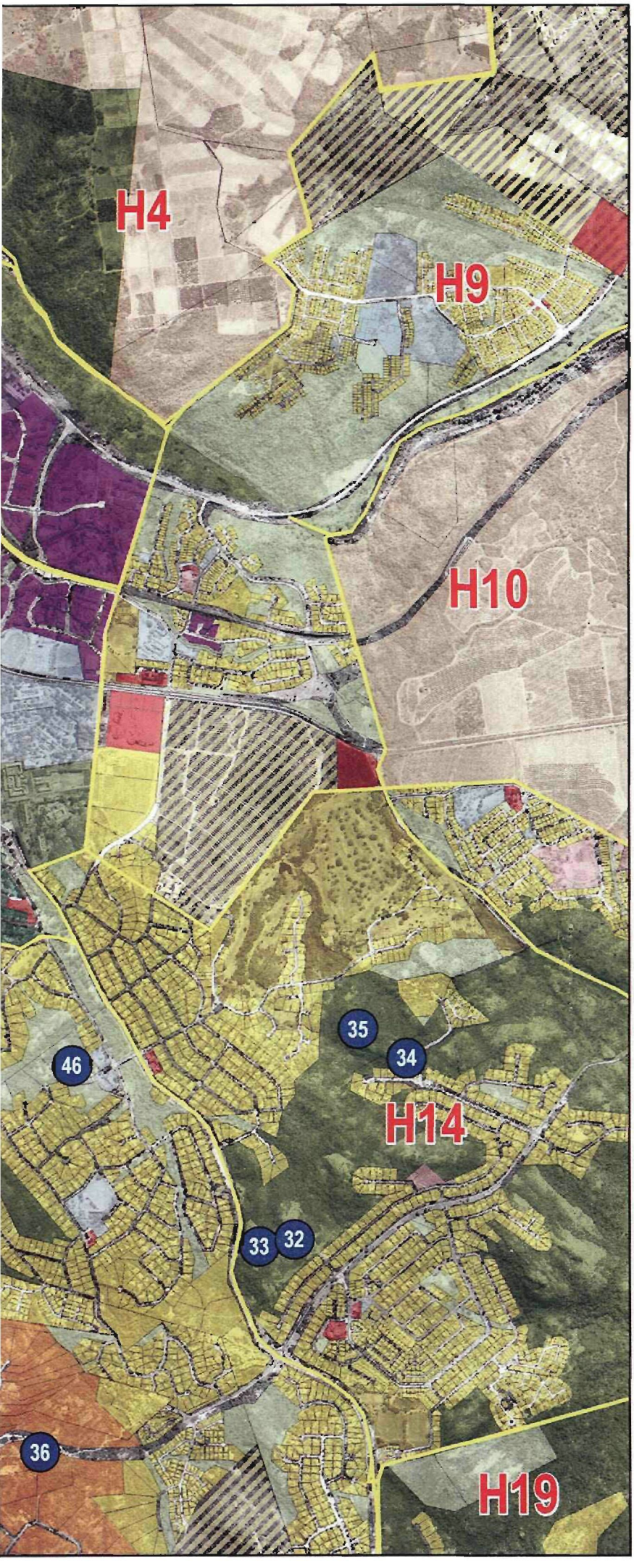


Figure 3.5: Aerial photo of Planning Area H (Nelspruit) with residential areas and relevé positions



PLANNING AREA H
RELEVE POSITIONS

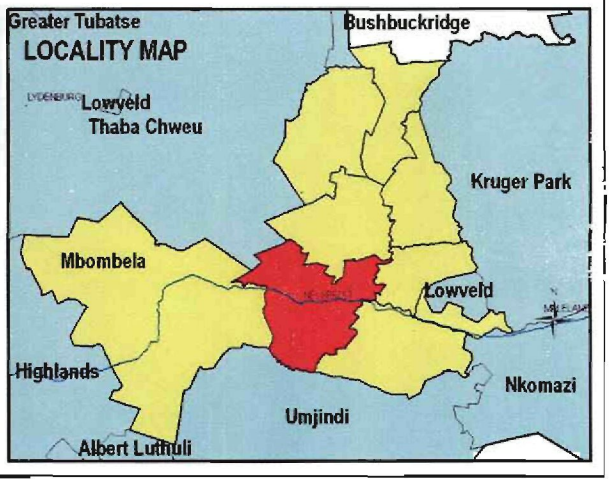
Legend

LUS 2006

- Agriculture
- Service Industry
- Rural Residential
- Business
- Utilities
- Community Facilities
- Entertainment
- Heavy Industrial
- Industrial
- Commercial/Industrial
- Education
- Cemetry
- Residential
- Future Residential
- Special
- Sport and Recreation
- Conservation
- Tourism and Accommodation
- Municipal
- Office
- Office/Residential
- Open Space

SCALE: 1:24,744

N



3.3 Vegetation description

3.3.1 Sampling procedures

The most sensitive areas in Mbombela are riparian vegetation/wetlands, grasslands and natural forests (Naidoo *et al.,* 2003). This current study concentrated on the ecologically sensitive areas such as wetlands/riparian zones, natural grasslands and hills/ridges and other woodland patches occurring on exposed granite outcrops within residential areas of Planning Areas A and H.

Stratification of the vegetation in the two Planning areas based on structure (trees / shrubs and grasses) and on location (wetlands and riparian areas, hills and ridges) were done using aerial photographs (1:15 000) and topographical maps. Relevés were compiled in 52 stratified sampling plots in ecologically sensitive open spaces of rural and urban residential areas.

The size of the sampling area within the identified relevés were fixed at $100m^2$ in the woodlands and hills/ridges, while sample plots in pockets on ridges and some wetlands/riparian were smaller ($5\text{-}10m^2$) to ensure that sampling was not done in ecotones. Sampling was carried out by a random walk procedure in the identified relevés within an area that was considered to be typical or representative of the specific relevé.

Plant species were then noted or collected for identification in all layers (grass, herb, shrub and tree) seen within the specific relevés. The description of vegetation was based on floristic data and taxa names were given according to the PRECIS floristic database of South Africa, managed by the South African National Botanical Institute (SANBI) in Pretoria (Germishuizen *et al.*, 2006). Sampling was done during January - April 2004 and December 2004 to April 2005.

3.3.2 Data collection and analysis

3.3.2.1 Vegetation and habitat information

To ensure standardised recording in the field, a data sheet was compiled according to Abendroth (2004) for the collection of more detailed information. Braun-Blanquet analysis, social, economic and conservation aspects formed part of the data sheet. The phytosociological analysis identified occurring plant communities and all floristic relationships between communities and their environment were recorded. In addition, estimated height and canopy cover averages for the trees, shrub and herbaceous strata were noted in each relevé. Habitat parameters recorded included topography, aspect, slope, soil forms and % rockiness. At each sample plot the type and intensity of human impact; such as trampling, waste dumping and cutting of trees were recorded on a scale from 0 to 3 (0 indicated no visible impact and 3 extensive impacts). To compromise social and economic aspects, additional information indicating specific use of plants like those used for medicine, food, beverages, construction,

skills or firewood were included from general information by Van Wyk and Gericke (2000), Van Wyk *et al.* (1997) and Van Wyk *et al.* (2002.) (Annexure B). An estimation of potential recreational and tourist use as well as the potential value of wildlife were included according to Abendroth (2003). See Data sheets, Annexure A.

The Braun-Blanquet scale, according to Kent and Coker (1992) and Mueller-Dombois and Ellenberg (1974) (Table 3.1), was used to estimate the cover abundance values of all the plant species present in a specific sample plot.

Table 3.1: Braun-Blanquet cover-abundance scales, with further diversion of scale 2 according to Mueller-Dombois and Ellenberg (1974)

Scale	Description
R	One or few individuals with less than 1% cover of total sample plot area
+	Occasional and less than 1% of total sample plot area
1	Abundant and with very low cover, or less abundant with higher cover, 1 - 5% cover of total sample plot area
2	Abundant with > 5 - 25% cover of total sample plot area, irrespective of the number of individuals
2a	> 5 - 12,5% cover, irrespective of the number of individuals
2b	> 12,5 - 25% cover, irrespective of the number of individuals
3	> 25 % - 50% cover of total sample plot area, irrespective of the number of individuals
4	> 50 - 75% cover of total sample plot area, irrespective of the number of individuals
5	> 75% cover of total sample plot area, irrespective of the number of individuals

3.3.2.2 Data Analysis

The description and definition of plant communities and their underlying environmental influences have to be analysed by using multivariate analysis techniques (Kent and Coker, 1992). To analyze the floristic data, an objective statistical classification technique, the TWINSPAN classification algorithm (Hill, 1979) and the TURBOVEG program (Hennekens, 1996a) were use for input, processing and data presentation and additionally the Braun-Blanquet procedures (Kent & Coker, 1992; Mueller-Dombois & Ellenberg, 1974) were implemented to refine these results. A visual editor for phytosociological tables (MEGATAB – Hennekens 1996b) was used to construct one table for Planning Areas A and H. The result of the final classification is presented in a phytosociological table (Table 4.1). Introduced species and weeds were clearly marked in the phytosociological table. Species which were encountered only once or twice during the study and had a relatively low cover are listed in

Table 4.2. The groupings of relevés in communities were confirmed by DCA-ordinations using the CANOCO program (Ter Braak, 1988).

3.4 Bird survey and classification of feeding and nesting guilds

Surveys done by members of BirdLife Lowveld in November 2004 and January 2005 were used for the study area in Planning Area A (Hazyview). Physical observation of birds (fly over, sit or calls) was noted on a data sheet (Annexure A) while walking for ten minutes through the different relevés (Figure 3.3). Identification of the birds was done according to Hockey *et al.* (2006), Sinclair *et al.* (2002) and Oberprieler (2001).

During the period of August 1979 to October 1980, a survey of birds in Nelspruit was undertaken to determine the status of avifauna within the municipal boundaries of the town (Lawson, 2001). Development and the rapid increase in human population were then considered to have had a marked effect on the avifauna. The original survey was conducted to form a basis for a later comparative survey to ascertain the effect of human influence on the bird life in a rapidly developing area of Nelspruit. This comparative survey was contributed by members of BirdLife Lowveld, Mpumalanga during the period August 1998 to August 2000. A follow-up of this survey will be done in 2008. The data in specific relevé positions of the 1998 – 2000 survey in Nelspruit was used for this study (Figure 3.5).

According to the classification of Smith (2004), birds were classified in seven different feeding guilds and 12 different nesting guilds. A numbering system was used to order the birds into the different feeding and nesting guilds found in the different plant communities (Table 3.2). The current study used the same classification of bird guilds found in the different plant communities (See Annexure C).

Table 3.2: Numbering system to order feeding and nesting guilds (Smith, 2004)

Nesting guilds	Number	Feeding guilds	Number
Tree nesters	1	Granivores	i
Structure nesters	2	Insectivores	ii
Tree/Structure nesters	3	Frugivores	iii
Reed/Grass nesters	4	Omnivores	iv
Ground nesters	5	Carnivores	v
Shrub nesters	6	Scavengers	vi
Shrub/Tree nesters	7	Herbivores	vii
Grass/ground nesters	8		
Shrub/Grass nesters	9		
Grass nesters	10		
Extra-limital	Ex		
Parasites	P		

Birds present in certain areas were evaluated according to their feeding and nesting guilds. It was assumed that if a bird was present in a certain area, the nesting and/or foraging sites were available in the specific biotope. Classification of the feeding and nesting guilds and names were according to Hockey *et al.* (2006), Smith (2004) and Tarboton (2001). No statistical analyses were completed for bird and other surveys, because sampling sites were all subjectively chosen to be reprehensive of specific plant communities.

3.5 Evaluation of Carbon Storage of Urban trees

Trees can lower the negative impact of the increasing levels of atmospheric carbon by sequestrating atmospheric carbon through their growth process (Nowak, 1993). The understanding of the relationship between urban trees, people and the environment can facilitate future urban designs that might enhance the environmental and social benefits from trees (Nowak *et al.*, 1996). Nowak (1994) has performed an analysis of carbon sequestration by individual trees as a function of tree diameter measured at breast height (dbh). He estimated that an average tree with a dbh of 31-46 cm (about 50cm^2 in crown area) sequestrates carbon at a rate of 19 kg/year. Akbari (2002) performed an analysis of the rate of carbon sequestration for several species of trees by using the data of Frelich (1992) that make use of age, dbh, crown area and height for 12 species of trees around Twin Cities in the USA. According to Frelich (1992), the rate of sequestration increases as trees grow in size. There is a direct link between the tree height and trunk diameter as well as percentage cover and tree height. The current study applied the statements from Nowak (1994) and Frelich (1992) that the taller a tree is and the higher the percentage tree cover, the more carbon will be stored. Nowak (1991) stated that carbon storage by trees is directly proportional to tree size. Trees directly benefit the

environment through the storing of carbon, and indirectly through reduced power plant emissions due to the savings in cooling and heating of buildings (Johnson & Gerhold, 2003).

The rapid growth of urban areas has increased the importance to restore degraded vegetation patches within urban areas (Ruiz-Jean & Aide, 2006). With the understanding of the relationship between urban trees, people and the environment, future urban designs might enhance the environment and reap other social benefits from trees (Nowak *et al.*, 1996). The quantification of urban tree carbon storage can lead to improved urban planning and management as well as human and environmental health (Myeong *et al.,* 2006). The effect of urban vegetation on reducing the adverse effects of urbanization has to be incorporated into long-term planning, policies and regulations to improve environmental quality (Nowak *et al.*, 2006).

The modelling of energy-use reduction and air pollution uptake associated with urban trees depend on diameter at breast height (dbh), crown height, crown diameter and leaf area to tree age. Peper *et al.* (2001) used parameters such as dbh, tree height, crown width, crown height and leaf area responses to model costs and benefits, analyze alternative management scenarios and determine the best management practice for sustainable urban forests. The dbh is an indictor for the amount of stored carbon and the relation of dbh and tree height had a correlation of r^2=0.86. Taller trees had thicker stems and more carbon could be stored (Peper *et al.*, 2001). Nowak (1991) stated that carbon storage by trees is directly proportional to tree size.

This current study used tree height as an indicator for a carbon storage value; percentage tree cover was assumed as the plant biomass and was also used as an indicator of carbon storage value. Because of the importance of the tree height and biomass for carbon storage calculation, both values have to be incorporated.

Trees in each plant community were ranked according to tree height and percentage tree cover, adapting a ranking method used by Cornelis and Hermy (2004). For this current study, the following classes were used: 1 (very low) to 4 (very high). The scores for tree height and biomass (% cover) were added to get a total carbon storage value for each plant community and biotope. The assumption was made that the plant community and biotope with the highest weighted value had the highest carbon storage value, see Table 3.3.

Table 3.3: Scores given to Tree height (m) and Cover (%), according to Cornelis and Hermy, 2004

Score value	Tree height (m)	Tree Cover (%)
1	1 - 2	10 – 25
2	3 - 4	26 – 40
3	5 - 6	41 – 55
4	7+	56+

3.6 Evaluation of biotopes worthy of protection and biotope mapping

In the current study, phytosociological data was used to identify different biotopes in the sensitive natural open spaces of Mbombela. All available data and information about the study area were combined and rated to determine an ecological value for a specific area. Such evaluation methods always include a certain amount of subjectivity.

The current study applied the four scales of Spellerberg (1994) to evaluate and prioritize communities by dividing them into 4 scales: nominal, ordinal, interval or ratio. Tans (quoted by Spellerberg, 1994) described a priority ranking where the evaluation method was designed to indicate the comparative ranking of an area when compared with other areas. Criteria were divided into 4 categories (biological, physical characteristics, degree of threat and availability of ownership) (Spellerberg, 1994). In this current study, three sections were used, namely vegetation, birds and habitat.

Freeman (1999) describes the Leeds survey methodology. It was designed to be compatible as far as possible with standard ecological surveys to facilitate transfer of information and to build on survey formats that have been successfully tried and tested elsewhere. According to Freeman (1999), a site evaluation based on the site survey was compiled. Quantitative values were assigned based on ecological, amenity and development criteria. The need to evaluate sites in urban areas, especially when dealing with a scarce resource such as a natural open space or development land, is becoming inescapable. Planners can use these values to compare the relative ecological and amenity merits of sites facing development so that efforts can be focused on conserving those sites whose ecology is deemed most valuable or threatened.

The approach of Freeman (1999) was used to construct an evaluation matrix in the current study. The matrix that was developed by Freeman (1999) included three sections representing ecological, amenity and development value. Each section consisted of six criteria which were ascribed values on a 0-5 scale. The choice of a 0-5 rating was used as a compromise between the need to keep the values as simple as possible and the need to represent a range of

conditions. All criteria would have equal weighting and maximum values. The three sections used in the current study consisted of four to five criteria which were ascribed values on a 1-4 scale.

After the field investigation and evaluation of data for this study, the evaluation data was divided in 3 sections; vegetation, birds and habitat. Every section had different evaluation criteria where vegetation had 5 criteria (Species richness, % Indigenous plans, Red Data Species, Carbon storage value), birds had 4 criteria (Species richness, Red data species, Feeding and Nesting guilds) and habitat had 4 criteria (Networking, Human impacts, Threats of adjacent land use and Socio-economic use/ educational/scientific use), see table 3.5. An average rating for each plant community were calculated and then combined for the calculation of each biotope. The average rating value was totalled for each section. These values were added for the final score to indicate the ecological value of the different biotopes.

Results of Freeman (1999) were collated and a composite summary table created to show the comparative amenity, ecological and development values for all sites. Sites could score a maximum of 30 for each category. The current study followed the same collated process, but the maximum value was 20 for vegetation and 16 each for birds and habitat.

A total score of the 3 evaluation sections (vegetation, birds and habitat) were incorporated and divided into 4 levels. The four levels obtains certain points where the lowest possible rating value obtained was 13 to the highest possible value obtained which was 52 (adopted method of Abendroth, 2004). The following indicative threshold values were proposed for evaluating the different biotopes worthy of protection:

13 - 23: = Low ecological value: Urgent need for rehabilitation.

24 – 34: = Medium ecological value: Rehabilitate and use management plans for protection of biodiversity.

35 - 45 = High ecological value: Management plans and proposed protection sites.

46 + = Extremely high ecological value: Should be protected at all cost in the urban context.

The description of the applied measurements method was according to Abendroth (2004) and was done on the sheet for the evaluation of investigated areas worthy of protection (Table 3.4). More information on the three categories of data used is given below and summarized in Table 3.5.

3.6.1 Vegetation information:

Vegetation information which is indicated in the first 5 rows of Table 3.5 included the following evaluation criteria used:

The total number of plant species (species richness) was scored in four levels:

1 = <20 species

2 = 20-40 species

3 = 41-60 species

4 = >60 species

Indigenous plants were expressed as a percentage of the total number of plants and were scored as follows:

1 = 0-22%,

2 = 23-55%

3 = 56-78%

4 = >79%.

The total number of Red data species was evaluated and scored according to Hilton-Taylor (1996):

1 = K+nt, where K = Insufficiently known; nt =Not threatened

2 = R+I, where R = Rare; I = Indeterminate

3 = V, where V =Vulnerable

4 = E, where E =Endangered.

Declared weeds and invaders (Henderson, 2001) were expressed as a percentage of the total number of plants and were scored in 4 levels as follows:

1 = >19

2 = 13-18

3 = 7-12

4 = 0-6.

Carbon storage value was based on tree height (m) and tree cover (%). A rating system was used to take both tree height and tree cover into account. See description of method in section 3.5 and rating system in Table 3.3. The added score value of tree height (m) and percentage tree cover were scored in 4 levels as followed:

1 = 1-2

2 = 3-4

3 = 5-6

4 = 7+

3.6.2 Bird information:

Bird information which is indicated in the second group of four rows of Table 3.5 included the following evaluation criteria:

The total number of bird species (species richness) was scored in four levels of:

1 = 1-25 species

2 = 26-50 species

3 = 51-75 species

4 = 76+ species

Species from the Red Data List (Barnes, 2000) were recorded and was scored in four levels of:

1 = DD + NE, where DD = Data deficient; NE = Not evaluated

2 = NT +LC, where NR = Near Threatened; LC = Least concern

3 = EN + VU, where EN =Endangered; VU =Vulnerable

4 = RE + CR where RE = Regionally Extinct; CR = Critically Endangered

The total number of feeding guilds was scored in four levels:

1 = 0-1 guilds

2 = 2-3 guilds

3 = 4-5 guilds

4 = 6+ guilds

The total number of nesting guilds was scored in four levels:

1 = 1-3 guilds

2 = 4-6 guilds

3 = 7-9 guilds

4 = 10-12 guilds

3.6.3 Habitat information

The habitat information is indicated in the last four rows of Table 3.5. The habitat criteria were evaluated by studying aerial photographs according to Part B of the assessment sheet (Table 3.4). The values (Table 3.4, number 15) were given to the different plant communities for networking after studying aerial photographs. Scores were summarized in four scales as follows:

1 = Isolated

2 = Low

3 = Moderate

4 = High

The human impact in and around the biotopes was measured by visual evaluation on site. An ordinal scale of 0 to 3 for the various impacts was developed by Abendroth (2004) (Table 3.4, number 16). The sum of the evaluation values was calculated and scored in four levels as follows:

1 = 25-32

2 = 17-24

3 = 9-16

4 = 0-8

The land use of adjacent areas has an impact on natural open spaces and was an important factor to include for evaluation of threats coming from adjacent areas. All biotope types which were adjacent to the sample plot and which might potentially influence the plot were noted and evaluated. Point 17 of the data sheet (Table 3.4) focuses on these aspects. Scores for adjacent land use were summarized in four levels (Table 3.5) as follow:

1 = very high

2 = high

3 = moderate

4 = low

People in rural residential/communal areas make use of natural vegetation for daily livelihood. Available literature was studied and all species with uses for medicine, food, beverages, crafts, aphrodisiacs, firewood and skills were counted and listed (See Annexure B). The socio-economic / educational / scientific impact in and around the biotopes was measured by visual evaluation on site and the number of useful plant species were counted and scored. An ordinal scale of 0 to 3 for was developed by Abendroth (2004 (Table 3.4, number 18). The sum of the evaluation values was calculated and scored in four levels as follows:

1 = 0-7

2 = 8-15

3 = 16-23

4 = 24+

3.7 Biotope Mapping

By applying the evaluation values, sensitive biotopes were identified and compiled into maps of the 2 selected Planning Areas. The maps were compiled by Mbombela Local Municipality in Arc GIS 9.2 from ESRI. This information will help set priorities for policy makers and further research projects in natural open spaces of Mbombela.

Table 3.4: Evaluation of habitat information on different sites.

B HABITAT INFORMATION / EVALUATION DATA		
[15] **Networking of biotopes/ Isolation:**		
	Isolated	- no other natural or semi-natural biotope types nearby - isolated by dense road networks, built-up areas e.g.
	Low	- few natural or semi-natural biotope types nearby (spots, linear elements), movements or exchange possible
	Moderate	- some natural or semi-natural biotope types nearby (bigger patches, linear elements), movements or exchange are possible
	High	- many natural or semi-natural biotope types close by, mosaics of different patches around, many current interactions

[16] **Impairment / human impacts in and around this plot:**
(0- not existing; 1- low, 2- moderate; 3- high)

Built up areas	.....	Use for recreation	.....	Bare patches	.....
Eutrophication	.....	Destruction of vegetation	.....	Grazing	.....
Biocidal influence	.....	Refuse disposal / Soil deposit	.....	Trampling	.....
Plant invaders	.....	Soil erosion	.....	Bush encroachment	.....
Traffic	.....	Noise	.....	Bad smell	.....
Others	.....				
			SUM IMPACTS		:.....

[17] **Threats of adjacent biotopes:**		
	Very high	- serious threats present, local eradication is possible - very high value of present transformation - must act as soon as possible
	High	- substantial effects, local eradication less possible - potential changes of management in adjacent areas possible
	Moderate	- small effects on quality or distribution of habitat - no threats by current management
	Low	- no negative effect on habitat - threats will not happen in > 10 years

[18] **Socio- economic/ educational scientific value: (Average / community)**
(0- not existing; 1- low, 2- moderate; 3- high)

Potential "flagship"- species*

Species with potential use for food beverages	.....
Species with potential use for timber, firewood, crafts	.....
Potential tourist and recreational use*	.....
Species with potential medical	.....
High value of wildlife/ nature education*	.....
AVG / COMMUNITY (*)	.....

Table 3.5: Evaluation criteria and values to calculate biotopes worthy of protection

C EVALUATION CRITERIA AND VALUES					
	Evaluation criteria	**1**	**2**	**3**	**4**
VEGETATION	Species richness (Plants)	< 20	20 - 40	41- 60	>60
	Indigenous Plants (%)	0 – 22	23 – 55	56 – 78	> 79
	"Red Data species"	K+nt	R+I	V	E
	Declared Weeds and Invaders (%)	>19	13-18	7-12	0-6
	Carbon storage value based on Tree Height (m) + Cover (%)	1-2	3-4	5-6	7+
	Total value of vegetation				
BIRDS	Species Richness (Birds)	1-25	26-50	51-75	76+
	Red Data List (Birds)	DD + NE	NT + LC	EN + VU	RE + CR
	Feeding guild diversity	0-1	2-3	4-5	6+
	Nesting guild diversity	1-3	4-6	7-9	10-12
	Total value of birds				
HABITAT	Networking of biotopes	Isolated	Low	Moderate	High
	Human impacts	25-32	17-24	9-16	0-8
	Threats of adjacent land use	Very high	High	Moderate	Low
	Socio- economic use/ educational / scientific	0-7	8-15	16-23	24+
	Total value of habitat				
	Total Value				

CHAPTER 4



Plant communities of selected sampling areas in Mbombela

CHAPTER 4

PLANT COMMUNITIES OF SELECTED AREAS IN MBOMBELA

4.1 Introduction

The natural open spaces in Mbombela Local Municipality, specifically in Hazyview (Planning Area A) and Nelspruit (Planning Area H) were surveyed during 2004 (Only the names Nelspruit and Hazyview will be used further on). The current study concentrated on riparian areas, hills and ridges and grasslands/valleys, which are regarded as the most sensitive areas for conservation as discussed in Chapter 3. This information will provide plant community data to municipal authorities and private consultation firms for future planning and environmental impact studies.

This chapter includes a detailed description of plant communities in the study area. Additionally, information on species richness, exotic plants (Henderson, 2001; Bromilow, 2001; Van Wyk *et al.*, 2002.), declared invaders and weeds (Henderson, 2001; Bromilow, 2001), and, in some applicable cases, also poisonous plants (Munday, 1988; Van Wyk *et al.*, 2002), and plants for medicinal and other uses (Van Wyk & Gericke, 2000; Van Wyk *et al.*, 1997) is discussed in this chapter. For specific information on medicinal plants and other plant uses, see Annexure B. More information will be given in Chapter 6, where gathered data and results have been mapped.

4.2 Classification – Phytosociological analysis

Species data from 52 relevés were analysed by using a two-way indicator species analysis program, TWINSPAN (Hill, 1979) as a first approximation, data were refined using Braun-Blanquet procedures and plant communities were identified. To determine correlations between the relevés and habitat characteristics, ordinations in the multivariate program, CANOCO (Ter Braak, 1988) was used.

From the phytosociological table (Table 4.1), 10 communities and 8 sub-communities were recognised as follows:

1 *Syzygium cordatum – Breonadia salicina* Riparian Woodland Community
   1.1 *Lantana camara – Breonadia salicina* Riparian Woodland Sub community
   1.2 *Ficus sycomorus - Breonadia salicina* Riparian Woodland Subcommunity
2 *Ficus sur – Tecoma stans* Riparian Woodland Community.
3 *Amaranthus hybridus – Acacia sieberiana* Riparian Woodland Community
4 *Pouzolzia mixta – Bauhinia galpinii* Riparian Woodland Community
5 *Englerophytum magalismontanum - Sterculia murex* Woodland Community

6 *Pappea capensis – Panicum maximum* Woodland Community

7 *Terminalia sericea – Agathisanthemum bojeri* Woodland Community

7.1 *Antidesma venosum – Terminalia sericea* Woodland Subcommunity

7.1.1 *Gerbera aurantiaca* variant

7.1.2 *Peltophorum africanum* variant

7.2 *Combretum molle – Dichrostachys cinerea* Woodland Subcommunity

8 *Cyanotis speciosa – Selaginella dregei* Herbaceous Open Woodland on exposed granite outcrops Community

8.1 *Bulbostylis hispidula* variant

8.2 *Cyperus rupestris* variant

8.3 *Myrothamnus flabellifolius* variant

9 *Xerophyta retinervis – Combretum molle* Herbaceous Open Woodland on exposed granite outcrops Community

9.1 *Polygala uncinata – Xerophyta retinervis* Herbaceous Open Woodland exposed granite outcrops Subcommunity

9.2 *Strychnos spinosa – Hyparrhenia hirta* Herbaceous Open Woodland exposed granite outcrops Subcommunity

10 *Lannea edulis – Hyparrhenia hirta Grassland* Community

A total of 549 plant species were identified in the two sampling areas of Mbombela, of which 71 (13%) were poisonous, 20 (4%) were declared weeds, 11 (2%) were declared invaders and 42 (8%) were exotic plant species. Plants that could be used by humans were 174 (32%) in total, of which 58 (11%) were for medicinal and other purposes. Only four (1%) of the plants were red data species and 186 (34%) were trees.

The phytosociological table with 10 communities and 8 sub-communities are shown in Table 4.1. Table 4.2 includes species that occurred only once and have low cover abundance. Table 4.3 includes species not belonging to a certain species group (Table 4.1) and with low cover abundance. Table 4.4 lists the average percentage cover and height of the different strata in the communities and Table 4.5 is a list of the average species per community and the percentage exotics, declared invaders and weeds Figure 4.1 is a dendrogram of the TWINSPAN classification of relevés on natural open spaces in Nelspruit and Hazyview. Figure 4.2 indicates the relative position of communities along the first two axes of a DCA-ordination of floristic data of natural open spaces in Mbombela Local Municipality, Nelspruit and Hazyview.

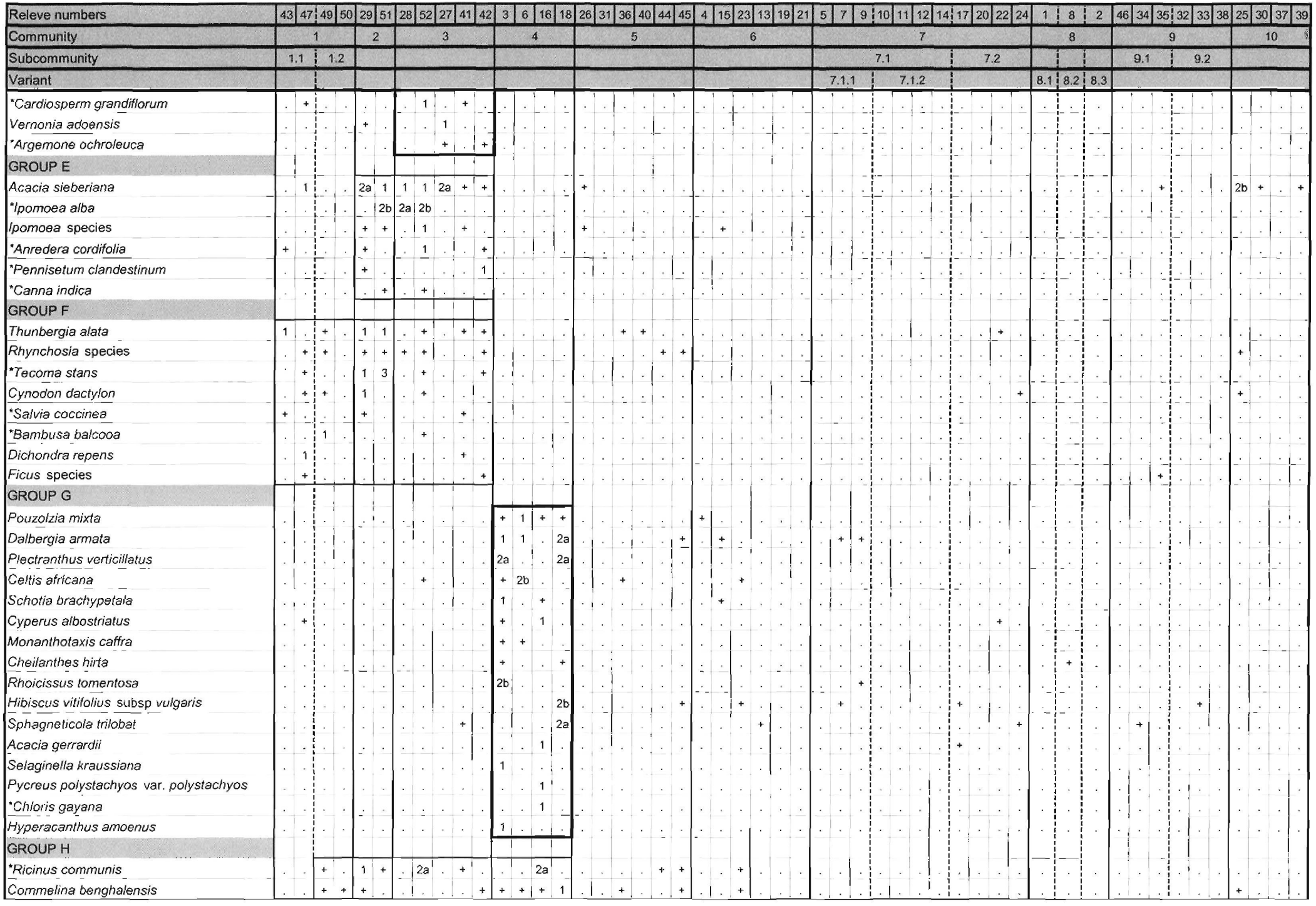
According to the dendrogram of the original TWINSPAN classification (Figure 4.1), one of the relevés (relevé 2) on top of the exposed granite outcrop in Hazyview was removed from the rest of the relevés on the first level of division. The remaining relevés were divided into two main

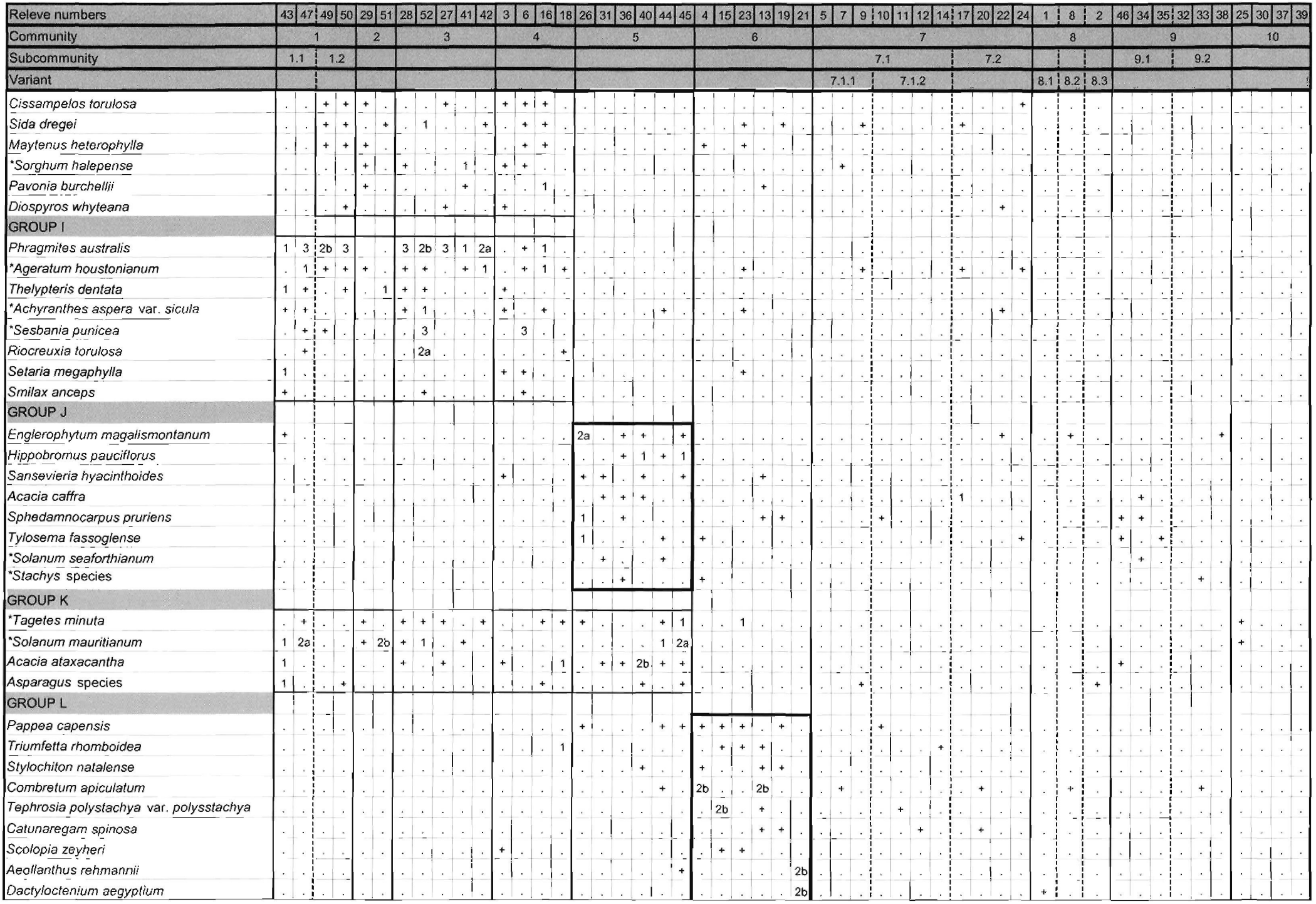
groups, A and B on the second level. On the third level, group A was divided in two groups, the riparian vegetation and a rehabilitated landfill site (relevé 48) of Nelspruit. The riparian vegetation of Nelspruit (Group A) was further divided into two groups (1, 2) on the fourth level. Group A1 was the natural riparian vegetation (community 1) that included the Crocodile River and the Nature Reserve in Nelspruit, while group A2 included the highly disturbed riparian vegetation in Nelspruit (communities 2, 3). These relevés were close to a shopping centre or next to industrial activities, while some others were in residential areas or close to the hospital and main road (N4).

Group B included the remaining communities on hills, granite outcrops, streams and grasslands of Hazyview and Nelspruit. It was further divided into the groups B1 and B2 on the third level of the classification. Group B1 was associated with streams and valleys in Hazyview and hills in Nelspruit. Group B1 was further divided in 2 groups on level four, where group 1 included the streams in Hazyview (community 4), the hills in Nelspruit (community 5) as well as 2 relevés of community 6 (relevés 4, 27, valleys in Hazyview). The second group of B1 included the valleys in Hazyview (communities 6, 7). The communities in Group B2 occurred on the exposed granite outcrops in Hazyview and Nelspruit and grasslands in Nelspruit. Group B2 was further divided into two groups on level four, where the grasslands (community 10) were removed from the exposed granite outcrops in Nelspruit (community 5, 9) and Hazyview (community 8).

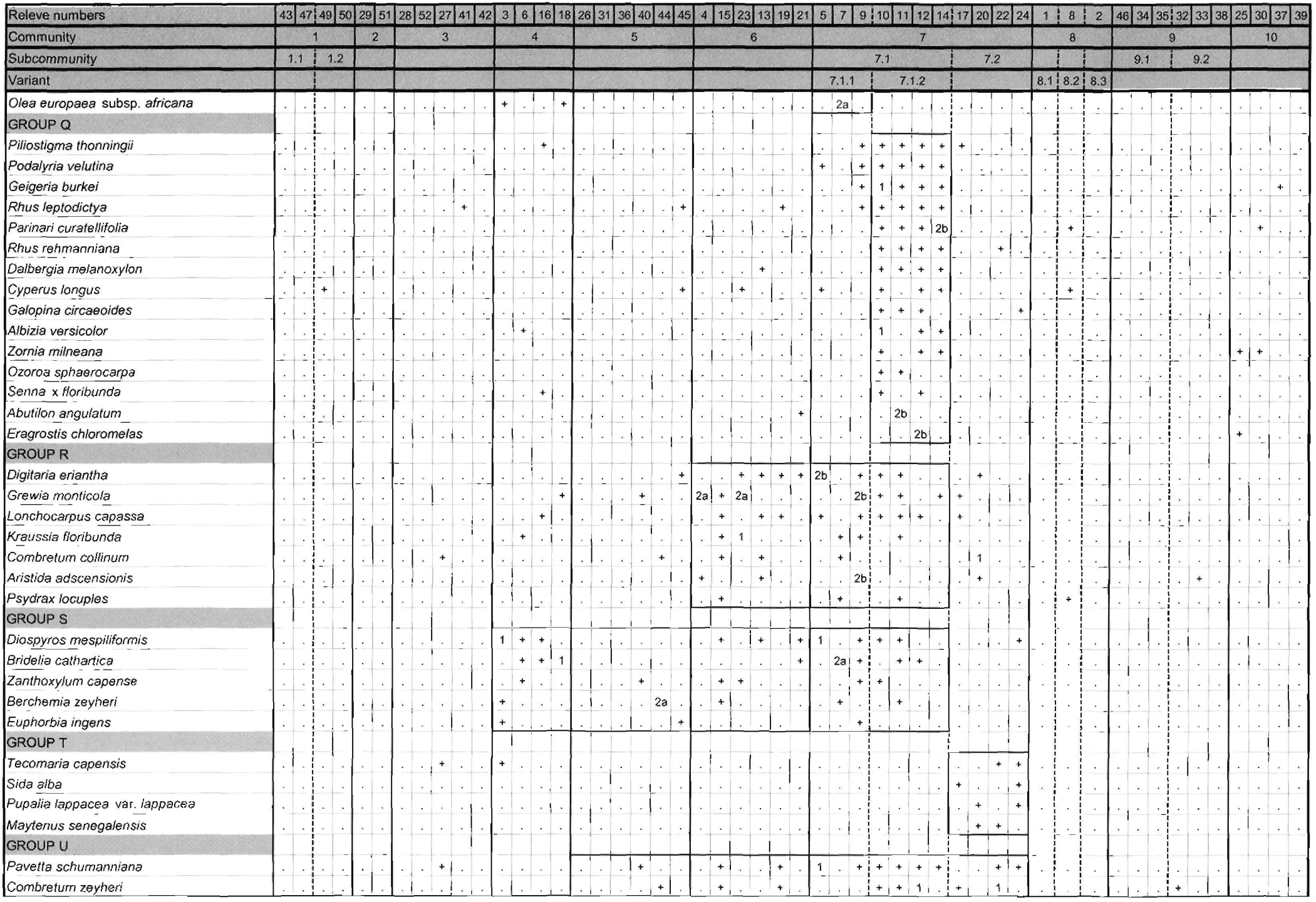
Table 4.1: A phytosociological table of natural open spaces in Hazyview and Nelspruit, Mbombela.

Releve numbers	43	47	49	50	29	51	28	52	27	41	42	3	6	16	18	26	31	36	40	44	45	4	15	23	13	19	21	5	7	9	10	11	12	14	17	20	22	24	1	8	2	46	34	35	32	33	38	25	30	37	39
Community	1				2		3					4				5						6						7												8			9						10				
Subcommunity	1.1		1.2																									7.1							7.2								9.1			9.2					
Variant																												7.1.1				7.1.2							8.1	8.2	8.3									
GROUP A																																																			
Breonadia salicina	2a	2a	3	3		+							+																																						
Syzygium cordatum	2b	1	1	2a																																															
Dietes species	+	+	1	+																																														
Caesalpinia rostrata		1	+	+																																														
**Ranunculus multifidus*		+	+	+																																													
**Melia azedarach*		+	+																																														
**Verbena venosa*		+	+																																														
Ludwigia octovalvis		+		+																																													
**Raphanus raphanistrum*		+		+																																													
**Pseudognaphaphalium luteo-album*		+		+																																													
**Morus nigra*		1																																															
**Oxalis corniculata*		1																																															
GROUP B																																																		
Ficus sycomorus			1	1																																													
Flueggea virosa			1	1																					+								+				+												
Bridelia micrantha			1	+																																													
Combretum erythrophyllum			+	1									+																																				
**Passiflora subpeltata*			+	+		+																																											
**Ranunculus* species			+	+																																													
Ipomoea plebeia			+				+																																									
Euclea crispa subsp. *crispa*			+																																													
Panicum schinzii			1																																													
Persicaria serrulata				+			+																																									
GROUP C																																																	
Ficus sur		+			+	2b																																										
**Tithonia diversifolia*					2b	+																																										
**Morus alba*					+	+																																										
Sida spinosa					+	+		+						+							+																											+
Trichilia emetica					+	+		+					+								+																											
GROUP D																																																	
**Amaranthus hybridus*					+		+	1		+	+												+										+															
Ipomoea cairica						+	+	1			+																																					
Cyanotis lapidosa	+						2b			+																																						
Acacia xanthophloea							+			+																																						
Neonotonia wightii							+			+																										+												

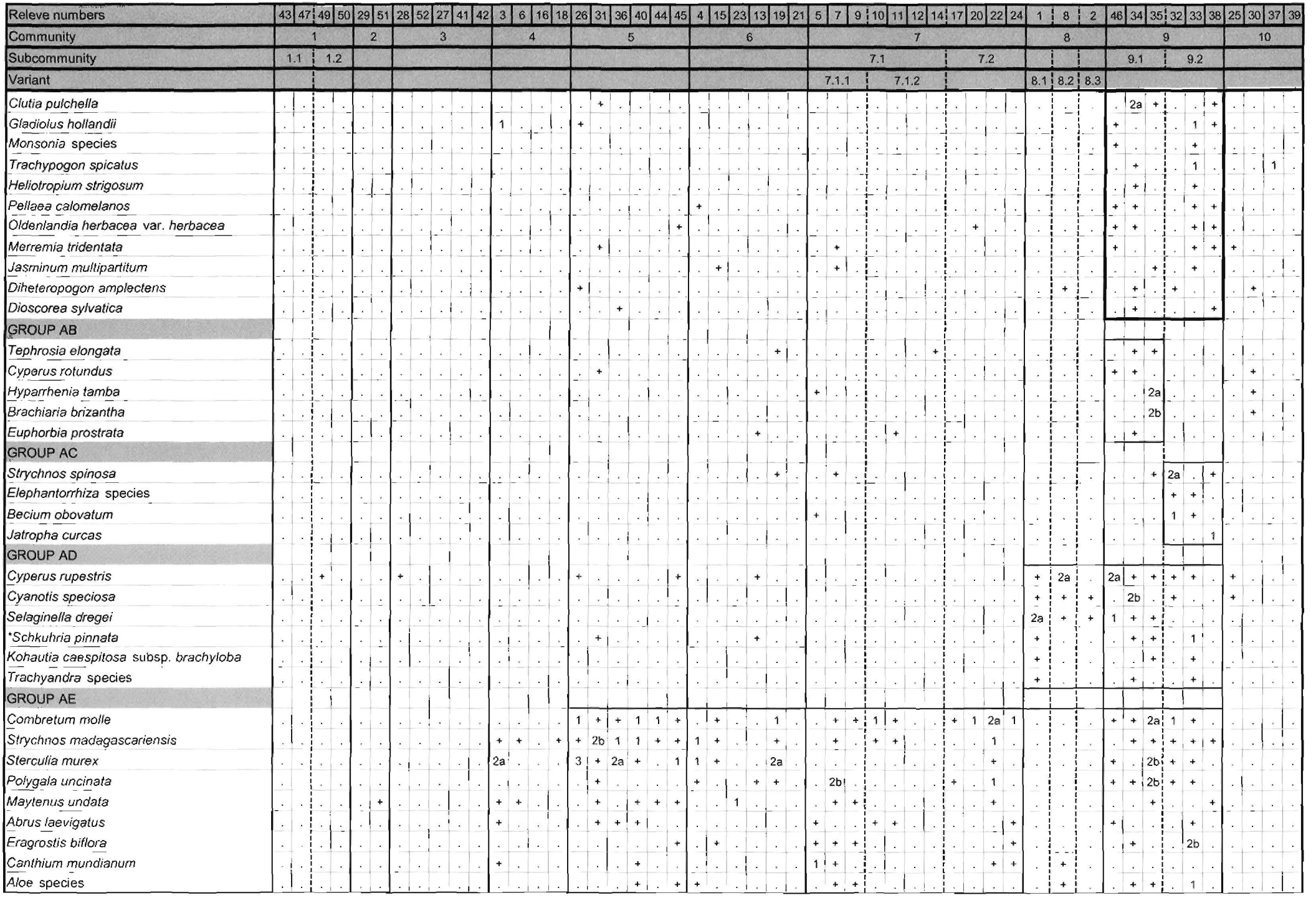

Releve numbers 43 47 49 50 29 51 28 52 27 41 42 3 6 16 18 26 31 36 40 44 45 4 15 23 13 19 21 5 7 9 10 11 12 14 17 20 22 24 1 8 2 46 34 35 32 33 38 25 30 37 39
Community 1 2 3 4 5 6 7 8 9 10
Subcommunity 1.1 1.2 7.1 7.2 9.1 9.2
Variant 7.1.1 7.1.2 8.1 8.2 8.3
*Cardiosperm grandiflorum
Vernonia adoensis
*Argemone ochroleuca
GROUP E
Acacia sieberiana
*Ipomoea alba
Ipomoea species
*Anredera cordifolia
*Pennisetum clandestinum
*Canna indica
GROUP F
Thunbergia alata
Rhynchosia species
*Tecoma stans
Cynodon dactylon
*Salvia coccinea
*Bambusa balcooa
Dichondra repens
Ficus species
GROUP G
Pouzolzia mixta
Dalbergia armata
Plectranthus verticillatus
Celtis africana
Schotia brachypetala
Cyperus albostriatus
Monanthotaxis caffra
Cheilanthes hirta
Rhoicissus tomentosa
Hibiscus vitifolius subsp vulgaris
Sphagneticola trilobat
Acacia gerrardii
Selaginella kraussiana
Pycreus polystachyos var. polystachyos
*Chloris gayana
Hyperacanthus amoenus
GROUP H
*Ricinus communis
Commelina benghalensis


Releve numbers
Community
Subcommunity
Variant
Cissampelos torulosa
Sida dregei
Maytenus heterophylla
*Sorghum halepense
Pavonia burchellii
Diospyros whyteana
GROUP I
Phragmites australis
*Ageratum houstonianum
Thelypteris dentata
*Achyranthes aspera var. sicula
*Sesbania punicea
Riocreuxia torulosa
Setaria megaphylla
Smilax anceps
GROUP J
Englerophytum magalismontanum
Hippobromus pauciflorus
Sansevieria hyacinthoides
Acacia caffra
Sphedamnocarpus pruriens
Tylosema fassoglense
*Solanum seaforthianum
*Stachys species
GROUP K
*Tagetes minuta
*Solanum mauritianum
Acacia ataxacantha
Asparagus species
GROUP L
Pappea capensis
Triumfetta rhomboidea
Stylochiton natalense
Combretum apiculatum
Tephrosia polystachya var. polysstachya
Catunaregam spinosa
Scolopia zeyheri
Aeollanthus rehmannii
Dactyloctenium aegyptium

Releve numbers	43	47	49	50	29	51	28	52	27	41	42	3	6	16	18	26	31	36	40	44	45	4	15	23	13	19	21	5	7	9	10	11	12	14	17	20	22	24	1	8	2	46	34	35	32	33	38	25	30	37	39
Community	1				2		3					4				5						6						7												8			9						10			
Subcommunity	1.1		1.2																									7.1						7.2									9.1			9.2						
Variant																												7.1.1			7.1.2								8.1	8.2	8.3									
Grewia hexamita																									2a																											
Sida rhombifolia		+																					2a																												
GROUP M																																																			
Ziziphus mucronata						+			+							+		+	+		+		+	+															2a												
Ficus glumosa																			+		+					+																									
Rhynchosia totta																	+	+	+			+			+	+					+															+					
Solanum panduriforme		+												+			+		+				+			+					+						+				+							1			
Ipomoea obscura		+	+										+					+	+		+				+	+											+							+							
Indigofera swaziensis	+				+														+	+		+			+	+								+		+												+		
Plectranthus species																		+							+		+																		+						
Hibiscus engleri																					+						+																	+							
Leonotis ocymifolia					+				+										+							+																									
Mimusops zeyheri																					+		+																			+									
Vigna vexillata								+													+		+																					+							
GROUP N																																																			
Terminalia sericea																			+	+			+					3	2a	+	3	2b	1	4	+	1	+	+							+					+
Agathisanthemum bojeri subsp. *bojeri*																	+						1			+		2a	+	+	+	+		2a		+	1	2a							+				+		
Euclea divinorum														+					+							+				+	1	+	+	+	2a		1	+												
Sida cordifolia													+										1						1	+	+	+	+		+		+	1													
Jasminum fluminense																							+							+		+				+	+	+												
Dicerocaryum eriocarpum																															+		+		+	+													
Combretum hereroense														+								+											+		3														
GROUP O																																																			
Antidesma venosum					+								+	+	+		+		+							+		2a		+	1	2a	1									+								
Heteropyxis natalensis												+		+									+			+			1	2a	+		3			+					+					+				
Trichoneura grandiglumis																	+												+	+	+		+	+			+												
Stylosanthes fruticosa																													+	+	+	+		1														+		+
Ximenia caffra																														+	+	+	+		+	+														
Hibiscus calyphyllus													+									+									+	+						+												
Striga species																									+							+	+				+												
Cyperus obtusiflorus													+																+				1																
Evolvulus alsinoides																															+	+								+									+
Hermannia glanduligera														+															+			+																+		
GROUP P																																																			
Gerbera aurantiaca									+																2a				+	+	+				+															
Kyllinga erecta																					+	+							+		+																			
Ocimum americanum var. *americanum*														+															+		+							+											
Tephrosia capensis																													+	+		+								1									
Digitaria diagonalis																														+	+																	


Releve numbers 43 47 49 50 29 51 28 52 27 41 42 3 6 16 18 26 31 36 40 44 45 4 15 23 13 19 21 5 7 9 10 11 12 14 17 20 22 24 1 8 2 46 34 35 32 33 38 25 30 37 39
Community 1 2 3 4 5 6 7 8 9 10
Subcommunity 1.1 1.2 7.1 7.2 9.1 9.2
Variant 7.1.1 7.1.2 8.1 8.2 8.3
Olea europaea subsp. africana
GROUP Q
Piliostigma thonningii
Podalyria velutina
Geigeria burkei
Rhus leptodictya
Parinari curatellifolia
Rhus rehmanniana
Dalbergia melanoxylon
Cyperus longus
Galopina circaeoides
Albizia versicolor
Zornia milneana
Ozoroa sphaerocarpa
Senna x floribunda
Abutilon angulatum
Eragrostis chloromelas
GROUP R
Digitaria eriantha
Grewia monticola
Lonchocarpus capassa
Kraussia floribunda
Combretum collinum
Aristida adscensionis
Psydrax locuples
GROUP S
Diospyros mespiliformis
Bridelia cathartica
Zanthoxylum capense
Berchemia zeyheri
Euphorbia ingens
GROUP T
Tecomaria capensis
Sida alba
Pupalia lappacea var. lappacea
Maytenus senegalensis
GROUP U
Pavetta schumanniana
Combretum zeyheri

Releve numbers	43	47	49	50	29	51	28	52	27	41	42	3	6	16	18	26	31	36	40	44	45	4	15	23	13	19	21	5	7	9	10	11	12	14	17	20	22	24	1	8	2	46	34	35	32	33	38	25	30	37	39
Community	1				2		3					4				5						6						7												8			9						10				
Subcommunity	1.1		1.2																									7.1							7.2								9.1			9.2						
Variant																												7.1.1			7.1.2								8.1	8.2	8.3										
Gymnosporia heterophylla					+														1	+			+	+							+	+	+	+	+			+													
Leucas martinicensis																								+	+											+			+													
GROUP V																																																				
Sclerocarya birrea					+			+				1		+		1			+	+	+	+	+		+	+		+		+		+	+	1	+				+												
Dombeya rotundifolia									+			1		+		+	+	+	1		+		+		2a	+			+		+		+	+			+	+													
Phyllanthus reticulatus					+								1	+	+						+	+	+	+		+			+		+	+	2a			+	+	+												
Senna petersiana								+					2a	+					+		+	+	+		+	+	+		+		+		+			1	+	+											
Rhus pentheri													+	1		+			+				+	1		+		1	+		1		+			+		+											
Euclea natalensis					+				+			+	+			+		+	+		+	+							+							+	+	1		+									
Sporobolus africanus														2a									+	+			+			+					+			+											
Coddia rudis									+			+		+								+	+		+										+		+											
Hypoestes forskaolii													+		+			+					+			+												+	+										
**Xanthium strumarium*														+										+											+														
Grewia flavescens													+	+									+									+	+					+											
GROUP W																																																			
Bulbostylis hispidula																												+											2a		3										
Euphorbia species																																							1		1										
Urochloa panicoides																																							+		+										
GROUP X																																																			
Coleochloa setifera																																							2b	+											
**Catharanthus roseus*										+											+																			1										
Leonotis leonurus					+																																			1										
**Digitalis purpurea*																+																							1										
GROUP Y																																																		
Perotis patens																									+	+		2a	+	+		+	+	1		+	+	+	2b	+										
Kohautia virgata																							1					1	+		+		+	+	+	+	+			+		+								
Ceratotheca triloba																			+		+					+	2a			+						+				+		+								
Cucumis hirsutus					+						1													+					+	+										+									
Asparagus buchananii																										+						+								+									
GROUP Z																																																		
Myrothamnus flabellifolius																																									2b										
Monopsis species																																									+										
Sarcostemma viminale																																									+	+									
GROUP AA																																																		
Xerophyta retinervis																																										1	2a	+	+	+						
Asclepias species																+					+																					+	+	+	+	2a						
Commelina africana								1													+	+	+																		+	+	+		+	+	+	+			
Hypoxis rigidula																																										+	2a	+		2a				+	+	
Pearsonia species																	+	+																								3				2a					


Releve numbers
43 47 49 50 29 51 28 52 27 41 42 3 6 16 18 26 31 36 40 44 45 4 15 23 13 19 21 5 7 9 10 11 12 14 17 20 22 24 1 8 2 46 34 35 32 33 38 25 30 37 39
Community
1 2 3 4 5 6 7 8 9 10
Subcommunity
1.1 1.2 7.1 7.2 9.1 9.2
Variant
7.1.1 7.1.2 8.1 8.2 8.3
Clutia pulchella
Gladiolus hollandii
Monsonia species
Trachypogon spicatus
Heliotropium strigosum
Pellaea calomelanos
Oldenlandia herbacea var. herbacea
Merremia tridentata
Jasminum multipartitum
Diheteropogon amplectens
Dioscorea sylvatica
GROUP AB
Tephrosia elongata
Cyperus rotundus
Hyparrhenia tamba
Brachiaria brizantha
Euphorbia prostrata
GROUP AC
Strychnos spinosa
Elephantorrhiza species
Becium obovatum
Jatropha curcas
GROUP AD
Cyperus rupestris
Cyanotis speciosa
Selaginella dregei
*Schkuhria pinnata
Kohautia caespitosa subsp. brachyloba
Trachyandra species
GROUP AE
Combretum molle
Strychnos madagascariensis
Sterculia murex
Polygala uncinata
Maytenus undata
Abrus laevigatus
Eragrostis biflora
Canthium mundianum
Aloe species

Releve numbers	43	47	49	50	29	51	28	52	27	41	42	3	6	16	18	26	31	36	40	44	45	4	15	23	13	19	21	5	7	9	10	11	12	14	17	20	22	24	1	8	2	46	34	35	32	33	38	25	30	37	39
Community	1				2		3					4				5						6						7											8			9						10			
Subcommunity	1.1		1.2																									7.1							7.2								9.1			9.2						
Variant																												7.1.1			7.1.2								8.1	8.2	8.3										
GROUP AF																																																				
Bauhinia galpinii	.	.	.	.	.	.	.	.	.	.	.	2b	1	.	2b	2b	+	+	1	+	+	.	+	1	.	+	.	1	.	.	.	.	.	.	2a	.	.	1	.	+	.	.	2a	.	.	+	.	.	.	.
Ochna natalitia	.	.	.	.	.	.	.	.	.	.	.	+	1	.	+	+	.	+	+	.	+	.	+	+	.	+	.	+	.	+	.	+	+	+	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.
Peltophorum africanum	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	+	.	.	.	+	.	+	.	.	+	.	.	1	.	+	.	.	+	.	1	+	1	+	.	+	.	.	.	1	.	+	.	.	.	.
Kalanchoe neglecta	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.
Commelina modesta	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Hyparrhenia species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.
GROUP AG																																																			
Lannea edulis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
**Veronica barbatonitis*	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	2b	.
Sebaea grandis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+
Felicia mossamedensis	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+
Bothriochloa insculpta	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+
Corchorus asplenifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+
Corchorus species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+
Blepharis species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	+
Schizachyrium sanguineum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.
Helichrysum acutatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Eriosema species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+
Crabbea hirsuta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Eragrostis racemosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Berkheya setifera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2a
Gazania krebsiana subsp. *serrulata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.
Cymbopogon excavatus	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b
Pterocarpus rotundifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.
Urochloa mosambicensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.
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Phyllanthus parvulus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	.	.	.	+	+	+	.	+	+	.	+	.	1	.	+	+	+	.	.	.
Helichrysum kraussii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2a	+	+	+	2b	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	2a	2b	.
Eragrostis species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	.	+	.	.	+	.	.	.	+	.	.	.	.	.	+	.	2a
Chamaecrista mimosoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	+	.	.	+	.	.	.	.	.	.	+	.	.	+	.
Vernonia oligocephala	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2b	+
GROUP AI																																																			
Aristida congesta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	2a	.	.	+	+	.	2a	+	+	+	2b	+	+	+	+	2b	.	2a	+	.	.	+	+	+	+	.	+
Heteropogon contortus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	+	+	.	+	.	+	+	+	+	+	+	+	2a	+	.	+	+	+	+	2a	.	+	.	+	.	+	.	.	+	.	+
Waltheria indica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	1	+	+	+	2a	+	2b	1	+	1	.	+	.	.	.	.	.	+	.	.	.	.	.	+
Pogonarthria squarrosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	2b	.	.	+	.	+	2b	+	+	+	.	+	.	+	+	+	.	.	.	.	+	1	.	.	.	+	.	+
Eragrostis curvula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	+	.	.	.	+	.	+	.	.	.	.	.	+	.	.	1	.	.	.	.	2b	.	.
Lantana rugosa	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	+	.	.	.	+	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.

Releve numbers	43	47	49	50	29	51	28	52	27	41	42	3	6	16	18	26	31	36	40	44	45	4	15	23	13	19	21	5	7	9	10	11	12	14	17	20	22	24	1	8	2	46	34	35	32	33	38	25	30	37	39
Community	1				2		3					4				5						6						7												8			9						10			
Subcommunity	1.1		1.2																									7.1						7.2									9.1			9.2						
Variant																												7.1.1			7.1.2								8.1	8.2	8.3										
Faurea saligna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	+				.	+	.	.	.	.	.	.	+	.
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Melinis repens	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	+	.	+	.	+	1	2b	+	+	+	+	+	1	+	.	+	+	.			+	+	.	1	2b	.	.	.	2a	+	.	+	+
Annona senegalensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	3	.	.	.	+	.	.	+	.	1	+	+	+	2a	+	+	.	2b	+	+			+	.	.	.	.	.	.	+	+	+	+
Loudetia simplex	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	+	.	2b	.	.	.			+	.	1	2b	+	2b	2a	1	.	+	+	+
Lannea discolor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	2a	.	.	+	+	.	+	.	.	.	+	.	.	.	1	.	+			.	.	.	.	+	+	2b	+	.	.	.	.	+
Rhoicissus tridentata	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2a	.	.	+	+	+	+	+	.	.	+	.	.	.	+	.	+	.	.	.	.	+	.			2b	.	.	.	.	.	.	.	.	.	+	.
Barleria obtusa	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2a	.	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+			.	.	.	+	+	.	.	+	+	.	+	+	.
Setaria sphacelata	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.			.	.	.	.	+	.	.	+	.	.	+	.	+
Senecio venosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	+	.	.	+	.	+	.	+	.	.	.	.			.	.	.	+	+	.	.	+	.	.	+	+	+
Diospyros lycioides	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	+	.	.	+	.	.	+	.	.	+	.	.	+	.	+	.			.	.	.	.	+	.	.	.	.	.	.	.	+
Tephrosia macropoda	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	+	.	.	.			.	.	.	+	.	.	.	.	.	.	.	.	+
**Paspalum dilatatum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.			.	.	.	.	.	.	+	.	.	.	.	.	+
Themeda triandra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	+	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	1	.	+	.	.	1	+	+	1
Helichrysum species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	+	.	+
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Cheilanthes viridis	.	.	.	.	.	.	+	.	.	.	.	+	+	.	+	+	+	+	.	+	+	+	.	+	+	+	.	.	+	+	+	.	.	+	.	.	+	+			+	1	.	1	+	+	1	+	+	+	.	.	.
Dichrostachys cinerea	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2b	+	+	.	2a	2a	.	1	+	.	+	+	+	2a	2b	+	+	+	1	+	+	2a	1	1			.	.	.	.	.	+	.	+	.	.	.	+	+
**Richardia brasiliensis*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	1	+	+	1	.	.	+	.	2a			+	+	.	.	.	.	+	.	.	+	.	.
Pterocarpus angolensis	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2b	+	.	+	.	+	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.			.	.	.	.	+	+	+	+	.	.	+	.	+
Vangueria infausta	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	.	.	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.			.	+	.	.	.	+	+	.	+	.	.	.	+
Helichrysum nudifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	.	+	.	.	.	+	.	.	.	+	.	+	.	+	+	.	.			.	.	.	.	.	.	.	.	.	1	2b	.	.
Hibiscus species	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.			.	.	.	.	.	.	+	.	.	.	+	.	.
GROUP AL																																																			
Acalypha villicaulis	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	+	2b	+	.	+			.	.	.	.	.	.	.	.	.	.	.	.	+
Solanum species	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.			.	.	.	.	.	.	.	.	.	+	+	.	.
Vernonia poskeana	.	.	.	.	+	.	.	.	1	.	.	.	+	3	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	+	.	+	.	.	.			+	+	.	.	2b	.	+	.	.	+	+	.	.
GROUP AM																																																			
Panicum maximum	.	.	.	.	+	+	+	+	+	2a	1	.	+	2a	+	2a	+	1	+	+	+	1	3	+	+	+	+	.	+	+	.	+	.	.	+	2a	.	+			.	.	.	.	+	1	+	.	+	.	2a	.	+
Hyparrhenia hirta	.	.	1	.	+	.	.	.	2a	.	.	.	.	.	.	+	+	.	+	.	.	.	+	.	.	.	.	+	.	2a	.	.	.	.	.	+	.	.			+	1	.	2a	.	+	2a	+	2a	2a	+	+	3
**Bidens pilosa*	.	.	+	+	+	.	.	+	+	.	+	.	.	+	.	.	.	+	+	.	1	.	+	+	+	.	.	.	+	.	+	.	.	+	.	.	+			.	.	.	.	.	.	+	2b	.	.	.	.	.
Panicum deustum	.	.	1	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	+	.	.	+	.	.	+	.	.	+	+	.	.	.	+	.	.			.	.	.	.	.	.	.	.	.	+	.	.	.
Panicum species	.	.	.	1	.	.	.	.	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+			.	.	.	.	.	2b	.	.	.	.	.	.	.
GROUP AN																																																			
**Lantana camara*	2a	2a	+	.	1	2a	2b	1	.	+	+	3	1	.	.	1	+	+	3	1	3	2a	1	.	2b	.	+	+	.	1	+	2b	2a	+	1	2a	1	.			.	+	.	+	2b	+	.	2a	2a	+	2b
**Conyza bonariensis*	.	+	.	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	.			.	.	.	.	.	.	.	.	.	.	+	+	
**Centella asiatica*	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.			.	+	.	.	.	.	.	.	.	.	.	.	.
Lippia rehmannii	.	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.	+

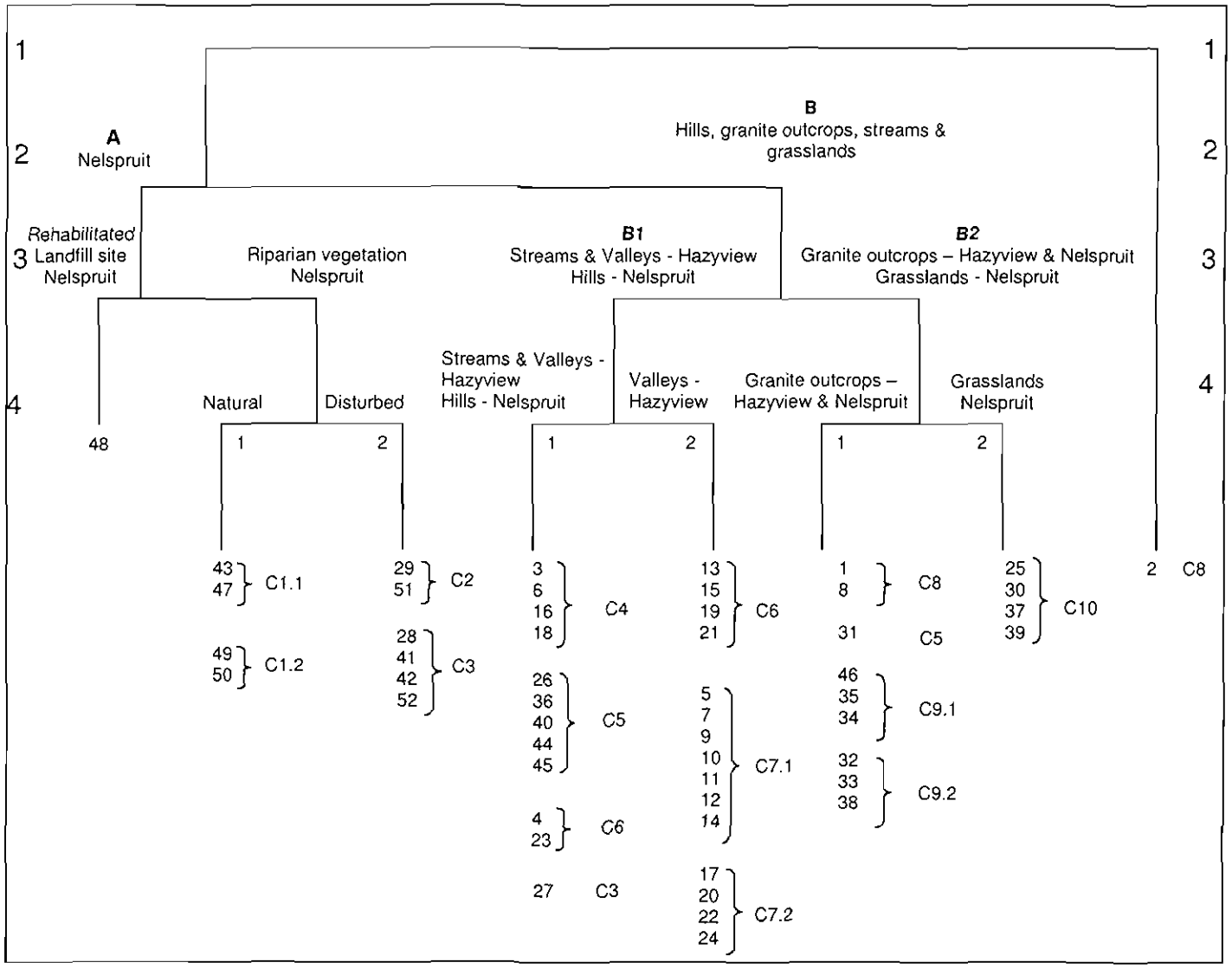


Figure 4.1: Dendrogram of the TWINSPAN classification of relevés in natural open spaces and identification of communities as in the final phytosociological table (Table 4.1) in Hazyview and Nelspruit, Mbombela.

Table 4.2: Plant species which occurred once and had a low cover-abundance value (* exotic species)

Species	Relevé (Cover)	Species	Relevé (Cover)	Species	Relevé (Cover)	Species	Relevé (Cover)
Subcommunity 1.1		**Community 4**		**Community 6**		**Community 8**	
Xysmalobium species	43(+)	*Zanthoxylum davyi*	3(+)	*Xerophyta* species	4(+)	*Eragrostis micrantha*	1(+)
Tarenna supra-axillaris	43(+)	*Orthosiphon labiatus*	3(+)	*Tragus racemosus*	4(+)	*Cynodon transvaalensis*	1(+)
Kalanchoe species	43(+)	*Haemanthus* species	3(+)	*Stapelia species*	4(+)	*Ximenia americana*	8(+)
Sporobolus fimbriatus	47(+)	*Flacourtia indica*	3(+)	*Ozoroa paniculosa*	4(+)	*Tephrosia rhodesica*	8(+)
Acalypha caperonioides	47(+)	*Pentas angustifolia*	6(+)	*Ochna arborea*	4(+)	**Araujia sericifera*	8(+)
Blepharis maderaspatensis	47(+)	*Premna mooiensis*	6(+)	*Momordica balsamina*	4(+)		
**Bromus catharticus*	47(+)	*Phoenix reclinata*	6(+)	*Englerophytum natalense*	4(+)	**Subcommunity 9.1**	
		Geniosporum angolense	6(+)	*Commiphora mollis*	4(+)	*Euphorbia cooperi*	46(1)
Subcommunity 1.2		*Pseudolachnostylis maprouneifolia*	16(+)	*Oldenlandia tenella*	23(1)	*Andropogon chinensis*	46(+)
Isoglossa species	49(+)	*Rhynchosia hirta*	16(+)	*Drimia* species	23(+)	*Basananthe triloba*	34(+)
Rhynchosia adenodes	49(+)	*Macrotyloma axillare*	16(+)	**Sonchus oleraceus*	23(+)	*Lolium* species	35(+)
Myrsine africana	50(+)	*Barleria saxatilis*	16(+)	*Oldenlandia affinis*	23(+)	*Acokanthera rotundata*	35(+)
		**Achyranthes aspera*	16(+)	*Gazania rigens*	23(+)		
Community 2		*Abutilon sonneratianum*	16(+)	*Lilium formosanum*	13(+)	**Subcommunity 9.2**	
Mucuna coriacea	29(+)	*Dombeya burgessiae*	18(1)	*Acalypha indica*	13(+)	*Agrostis* species	32(+)
Mikania capensis	29(+)	*Schrebera alata*	18(+)	*Hibiscus micranthus*	13(+)	*Brachiaria eruciformis*	33(+)
Erythrina lysistemon	29(+)	*Ficus thonningii*	18(+)	*Sonchus wilmsii*	19(+)	*Tephrosia multijuga*	33(+)
**Ligustrum ovalifolium*	29(+)			*Oplismenus hirtellus*	19(+)	*Solanum incanum*	33(+)
**Leucaena leucocephala*	29(+)	**Community 5**		*Indigofera arrecta*	19(+)	*Pavetta edentula*	33(+)
Rauvolfia caffra	51(+)	*Catha edulis*	26(1)	*Dalechampia capensis*	19(+)	*Orbea* species	33(+)
Brachiaria nigropedata	51(+)	*Maytenus tenuispina*	26(+)	*Alectra sessiliflora*	19(+)	*Lannea schweinfurthii*	33(+)
		Hyparrhenia collina	26(+)	*Rhynchosia nitens*	19(+)	*Enteropogon macrostachyus*	33(+)
Community 3		*Argyrolobium* species	31(+)			*Thunbergia pondoensis*	38(+)
Senecio serratuloides	28(+)	*Strychnos cocculoides*	31(+)	**Subcommunity 7.1**		*Geranium* species	38(+)
Panicum repens	28(+)	*Crassula swaziensis*	31(+)	*Burkea africana*	5(1)	*Commelina eckloniana*	38(+)
**Verbena bonariensis.*	28(+)	*Ruellia patula*	36(+)	*Hoslundia opposita*	5(+)		
Trema orientalis	52(1)	*Rhynchosia caribaea*	36(+)	**Dactylis glomerata*	7(+)	**Community 10**	
**Cortaderia* species	52(+)	*Polygala albida*	36(+)	*Combretum* species	7(+)	*Nidorella* species	25(+)
**Populus alba*	52(+)	*Dioscorea cotinifolia*	36(+)	*Hyptis pectinata*	9(+)	*Lactuca inermis*	25(+)
**Nicandra physalodes*	52(+)	*Allophylus transvaalensis*	36(+)	*Crotalaria lanceolata*	9(+)	*Talinum caffrum*	25(+)
**Ipomoea purpurea*	52(+)	*Scolopia stolzii*	40(+)	*Buchnera* species	10(+)	*Portulaca oleracea*	25(+)
**Impatiens sylvicola*	52(+)	*Scadoxus puniceus*	40(+)	*Hyparrhenia dichroa*	10(+)	*Albuca* species	25(+)
Tephrosia retusa	27(+)	*Gerbera jamesonii*	40(+)	*Acridocarpus natalitius*	10(+)	*Ruellia* species	30(+)
Rubia cordifolia subsp *conotricha*	27(+)	*Cheilanthes involuta*	40(+)	*Pachystigma latifolium*	11(+)	*Acacia* species	30(+)
Rhus rigida	27(+)	*Acacia davyi*	40(+)	*Eragrostis chapelieri*	11(+)	*Morella brevifolia*	30(+)
Macrotyloma maranguense	27(+)	*Teclea natalensis*	44(+)	*Crassula vaginata*	11(+)	*Hypoxis acuminata*	30(+)
Ledebouria ovatifolia	27(+)	*Rhus chirindensis*	44(+)	*Galium spurium*	12(+)	*Albizia harveyi*	37(1)
Cymbopogon validus	27(+)	*Combretum woodii*	44(+)	*Scabiosa columbaria*	14(+)	*Ochna serrulata*	37(+)
Thunbergia natalensis	42(+)	*Erythrina latissima*	45(+)	*Spermacoce natalensis*	14(+)	*Helichrysum aureonitens*	37(+)
		Crinum graminicola	45(+)	*Tephrosia burchellii*	14(+)	*Gerbera ambigua*	37(+)
		Brachiaria deflexa	45(+)			*Crabbea galpinii*	37(+)
		Barleria elegans	45(+)	**Subcommunity 7.2**		*Berkheya insignis*	37(+)
		Aneilema aequinoctiale	45(+)	*Cymbopogon plurinodis*	17(1)	*Andropogon gayanus*	37(+)
		Dactyloctenium giganteum	45(+)	*Cotyledon barbeyi*	22(+)	*Tephrosia lupinifolia*	39(+)
				Rotheca myricoides	24(+)	*Nidorella auriculata*	39(+)
				Ehretia rigida	24(+)		
				Cassine papillosa	24(+)		

Table 4.3: Plant species which occurred in more than one relevé and had a low cover-abundance value (* exotic species)

Species	Relevé (Cover)	Species	Relevé (Cover)
Vepris reflexa	18, 44, 45(+)	*Cussonia spicata*	27, 3, 35 (+)
Grewia caffra	3, 40, 45, 4(+)	*Oxalis* species	43, 27, 5, 9 (+)
Grewia occidentalis	3, 36(+)	*Rottboelia cochinchinensis*	28, 27, 40 (+)
**Bidens bipinnata*	6, 26, 8(+)	*Ruellia cordata*	27, 44, 4 (+)
**Digitaria sanguinalis*	6, 45(+)	*Euphorbia heterophylla*	42, 44 (+)
Triumfetta pilosa	6, 45(+)	**Chromolaena odorata*	52, 45 (+)
Triumfetta annua	28, 6, 44, 30(+)	*Acacia karroo*	28, 40 (+)
Habenaria epipactidea	7, , 22(+)	*Lablab purpureus*	4, 24 (+)
**Gomphrena celosioides*	52, 5, 17(+)	*Ehretia amoena*	13, 24 (+)
Clematis brachiata	27, 40, 12, 24(+)	*Kalanchoe brachyloba*	19, 22 (+)
Oxalis obliquifolia	12, 22(+)	*Momordica foetida*	15, 24 (+)
Hyperthelia dissoluta	14, 22(+)	*Rorippa nudiuscula*	6, 24 (+)
Justicia flava	9, 22(+)	*Rhynchosia minima*	6, 22(+)
Eragrostis superba	4(1), 20, 32(+)	*Dicliptera* species	3, 24 (+)
Ipomoea eriocarpa	42, 17(+)	*Crotalaria spartea*	50, 21, 6, 9 (+)
Zornia glochidiata	45, 46(+)	**Psidium guajava*	49, 14 (+)
Kalanchoe paniculata	36, 12, 38(+)	*Mariscus congestus*	47, 19, 34(+)
Erythroxylum delagoense	44, 46(+)	*Tetradenia riparia*	13, 8 (+), 34(1)
Cyanotis lanata	45, 33(+)	*Digitaria longiflora*	1, 32 (1)
Adenia digitata	45, 32(+)	*Cleome* species	40, 8, 34 (+)
Gnidia caffra	40, 37(+)	*Tragia meyeriana*	36, 15, 17, 34 (+)
Ancylobotrys capensis	40, 37(+)	*Cyphostemma* species	26, 15, 17, 32 (+)
Crassula alba	16, 13, 34(+)	*Jasminum stenolobum*	36, 19, 33 (+), 22 (1)
Lippia javanica	47, 10, 39(+)	*Polygala hottentotta*	45, 10, 38(+)
Apodytes dimidiata	50, 23,38(+)	**Passiflora suberosa*	44, 19, 32 (+)
Cucumis zeyheri	16, 25(+)	*Tricliceras tanacetifolium*	45, 1, (+)
Privia cordifolia	15, 9(+)	*Senecio consanguineus*	46, 38, 25 (+)
Melhania prostrata	4, 10(+)	*Diospyros galpinii*	8, 37 (+)
Oldenlandia corymbosa var *caespitosa*	7, 8(+)	*Crossandra greenstockii*	7(+), 37(1)
Dipcadi viride	5, 33(+)	*Sonchus nanus*	17, 30 (+)
Combretum imberbe	14, 34(+)	*Vernonia natalensis*	10, 30 (+)
Hibiscus cannabinus	6, 1(+)	*Pseudarthria hookeri*	10, 39 (+)
Hyparrhenia cymbaria	28(+), 37(1)	*Vernonia sutherlandii*	12, 50(+)
Hypoxis hemerocallidea	27, 25 (+)	*Desmodium* species	52, 39 (+)

4.3 Description of plant communities

1 *Syzygium cordatum – Breonadia salicina* Riparian Woodland Community

The *Syzygium cordatum - Breonadia salicina* Riparian Woodland Community represented natural riparian vegetation on banks of the Crocodile River and streams in Nelspruit. The soil type was alluvial deposits with a high clay percentage (> 30%).

Differential species for this community were the species in Species group A (Table 4.1). These species included indigenous tree species such as *Breonadia salicina* (also the dominant species) and *Syzygium cordatum,* exotic tree species such as *Morus nigra* and *Melia azedarach,* shrubs such as *Caesalpinia rostrata* and *Ludwigia octovalvis* and forbs such as *Dietes* species, *Verbena venosa* and *Oxalis corniculata.*

The average tree height in this community was 7m with 42% cover, shrub height 1.7m with 25% cover, grass height 44cm with 40% cover and the forb height was 26cm with 30% cover (Table 4.4). An average number of 34 species per relevé was recorded of which 23% were exotics, 4% were declared invaders and 11% were declared weeds (Table 4.5). *Melia azedarach* is a declared invader and poisonous to humans (Henderson, 2001).

Two sub-communities could be distinguished in this community, based on species composition as well as on the degree of disturbance. Subcommunity 1.1 could be distinguished from subcommunity 1.2 based on the presence of species in Species group K and the absence of species in Species group B, H and AM. Subcommunity 1.1 was represented by two relevés, 43 and 47. Relevé 43 was in the Nelspruit Nature Reserve and relevé 47 was next to the Crocodile River and a food processing plant. Although both relevés were in natural areas, more anthropogenic impacts were visible than in subcommunity 1.2. Subcommunity 1.2 was represented by two relevés, 49 and 50. Relevé 50 was next to the Crocodile River in the Lowveld Botanical Garden and relevé 49 was between the Crocodile River and an industrial park, close to the Botanical Garden. Relevé 50 was well managed and fewer anthropogenic impacts were visible than in subcommunity 1.1.

1.1 *Lantana camara - Breonadia salicina* Riparian Woodland Subcommunity

The *Lantana camara –Breonadia salicina* Riparian Woodland subcommunity, was situated in the Nelspruit Nature reserve and on the banks of the Crocodile River, close to a fruit processing plant in Nelspruit. The soil was alluvial deposits with a surface rockiness of 30%.

Although no differential species occur in this subcommunity, it was characterized by a high cover of exotic declared weeds such as the dominant species *Lantana camara* (Species group AN, Table 4.1) and *Solanum mauritanum* (Species group K, Table 4.1) as well as other exotic

declared weeds with a low cover such as *Cardiospermum grandiflorum* (Species group D, Table 4.1), *Tecoma stans* (Species group F, Table 4.1), *Achyranthus aspera* and *Sesbania punicea* (Species group I, Table 4.1). These declared weeds distinguished the *Lantana camara* - *Breonadia salicina* subcommunity from the *Ficus sycomorous* - *Breonadia salicina* subcommunity. Subcommunity1.1 was also distinguished from subcommunity 1.2 based on the absence of species in Species Group B, H and AM (Table 4.1)

The average tree height in this community was 4m with 31% cover; shrub height was 1.5m with 21% cover, grass height was 60cm with 60% cover and forb height was 40cm with 50% cover (Table 4.4). An average of 33 species per relevé was recorded of which 25% were exotics, 3% were declared invaders and 17% were declared weeds (Table 4.5).

1.2 *Ficus sycomorus - Breonadia salicina* Riparian Woodland Subcommunity

The *Ficus sycomorus- Breonadia salicina* Riparian/Wetland Subcommunity also occurred along the Crocodile River and formed part of the Lowveld Botanical Garden. The main soil type was alluvial deposits. This subcommunity was characterized by well-developed tree species that formed the tallest tree stratum (10m) of all communities, and included the following tree and shrub species which were all differential species: *Ficus sycomorus, Flueggea virosa, Bridelia micrantha* and *Combretum erythrophyllum (*Species group B, Table 4.1). Although this subcommunity could be regarded as less disturbed than the *Lantana camara* - *Breonadia salicina* Subcommunity, exotic invaders and declared weeds were recorded with low cover abundance and included species such as *Melia azedarach* and *Raphanus raphanistrum (*Species group A, Table 4.1), *Cynodon dactylon, (*Species group F, Table 4.1), *Ricinus communis (*Species group H, Table 4.1), *Ageratum houstonianum, Sesbania punicea* (Species group I, Table 4.1) *Bidens pilosa* (Species group AM, Table 4.1), *Lantana camara* (Species group AN, Table 4.1) and *Psidium guajava* (not in a specific group, Table 4.3). In addition to the differential species (Species group B, Table 4.1) this subcommunity was further characterized by the presence of species in Species Group H and AM (Table 4.1).

The average tree height in this community was 10m, the tallest tree stratum of all communities described, with 52% cover, shrub height was 1.9m with 30% cover, grass height was 28cm with 20% cover and forb height was 13cm with 10% cover (Table 4.4). An average number of 36 species per relevé was recorded of which 21% were exotic, 6% were declared weeds and 6% were declared invaders (Table 4.5).

2 *Ficus sur – Tecoma stans* Riparian Woodland Community.

This community consisted of two relevés representing a stream in Nelspruit adjacent to an industrial area and a stream close to a pathway (walkway) from a residential area to a shopping

centre. The land use of adjacent areas did have an impact on the species composition of this community as a result of direct anthropogenic influences. People were washing their clothes in the stream next to the industrial area, while a bad smell and refuse dumping were apparent in the other stream.

Species of species group C (Table 4.1) were the differential species in the *Ficus sur–Tecoma stans* Community which consisted of indigenous tree species such as *Ficus sur* and *Trichillia emetica* and indigenous forbs such as *Sida spinosa*. The other differential species were exotic declared invaders and weeds such as *Morus alba* and *Tithonia diversifolia.* Other important invaders and declared weeds were *Tecoma stans* (Species group F, Table 4.1), which was also the dominant species, *Ricinus communis* (Species group H, Table 4.1), *Solanum mauritianum* (Species group K, Table 4.1) and *Lantana camara* (Species group AN, Table 4.1). Other species observed in this community were *Acacia sieberiana* (Species group E, Table 4.1), *Thunbergia alata, Rhynchosia* species (Species group F, Table 4.1) and *Panicum maximum* (Species group AM, Table 4.1).

The average tree height in this community was 6m with 23% cover, shrub height was 1m with 10% cover, grass height was 55cm with 10% cover and forb height was 50cm with 40% cover (Table 4.4). An average number of 36 species per relevé was recorded of which 35% were exotics (the highest percentage per community in the entire study area), 13% were declared invaders and 17% were declared weeds (Table 4.5).

3 *Amaranthus hybridus – Acacia sieberiana* Riparian Woodland Community

The *Amaranthus hybridus - Acacia sieberiana* Riparian Woodland Community was identified on the banks of the streams in Nelspruit's CBD and residential areas. Some streams were seasonal and flowed only during the summer, while others were flowing throughout the year. The streams flowing to the Crocodile River had a slope of about 5%. The soil in these areas varied from alluvial deposits to sandy soil with a soil surface rockiness that varied between 0 - 5 percent. There were two separate vegetation units, the vegetation on the banks of the streams (trees, shrubs, forbs and grasses) and the vegetation in the streams (*Phragmites australis*). It was classified together as riparian vegetation due to the definite growth form on the aerial photo of *Acacia sieberiana* on the banks and *Phragmites australis* in the streams. Some of the sites were highly disturbed with garden and domestic waste. There was also evidence of burning in some areas. Homeless people spending the nights in the riparian areas have caused regular burning during the winter, as well as the bad smell in these areas.

The differential species of this community were the species in Species group D (Table 4.1) and include forbs such as *Amaranthus hybridus, Ipomoea cairica and Cyanotis lapidosa.* The

dominant tree species was *Acacia sieberiana* (Species group E, Table 4.1) while shrubs such as *Lantana camara* (Species group AN, Table 4.1) and grass species such as *Panicum maximum* (Species group AM, Table 4.1) also occurred in the community on the banks of the streams. The dominant species of this community in the streams was the reed *Phragmites australis* (Species group I, Table 4.1). The species of Species group E (Table 4.1) indicated an affinity between this community and the *Ficus sur – Tecoma stans* Community, while species group F (Table 4.1) occurred in most of the riparian communities of Nelspruit (Communities 1, 2 and 3). Other species worth mentioning were *Ricinus communis* (Species group H, Table 4.1), *Ageratum houstonianum, Sesbania punicea, Riocreuxia torulosa* (Species group I, Table 4.1), *Tagetes minuta, Solanum mauritianum* (Species group K, Table 4.1) and *Bidens pilosa* (Species group AM, Table 4.1). *Combretum collinum* (Species group R, Table 4.1) listed in the Red data List of Southern African Plants (Hilton-Taylor, 1996) as K (suspected but uncertain of status) was also described in this community.

The average tree height in this community was 6m with 30% cover, shrub height was 1.2m with 15% cover, grass height was 90cm with 6% cover and forb height was 38cm with 57% cover, which was the highest forb cover of all the communities described (Table 4.4). An average number of 32 species per relevé was recorded of which 26% were exotics, 4% were invaders and 18% were declared weeds. This species diversity in this community was one of the lowest with an average of 32 species per relevé and the highest percentage (18%) of declared weeds occurred here, probably as a result of direct anthropogenic influences (Table 4.5).

4 *Pouzolzia mixta – Bauhinia galpinii* Riparian Woodland Community

This community occurred on the banks of the Sand River and streams in Hazyview. Erosion in the Sand River was common and natural destruction of vegetation was high. Anthropogenic influences had an effect on the plant diversity and disturbance in this community. The soil varied from alluvial deposits with a high clay percentage to deep sandy soils, while the rockiness of the soil surface was only 5%.

The differential species were the species of Species group G (Table 4.1), which included trees such as *Celtis africana* and *Schotia brachypetala,* shrubs such as *Pouzolzia mixta* and *Dalbergia armata* and forbs such as *Plectranthus verticillatus, Cyperus albostriatus, Cheilanthus hirta, Rhoicissus tomentosa, Hibiscus vitifolius and Sphagneticola trilobata.* The co-dominant species of this community were the indigenous forb *Pouzolzia mixta* (Species group G, Table 4.1) and the exotic forb *Commelina benghalensis* (Species group H, Table 4.1), while the indigenous shrub *Bauhinia galpinii* (Species group AD, Table 4.1) was present in all but one of the relevés. Other species worth mentioning were the trees *Diospyros mespiliformis* (Species group S, Table 4.1), *Strychnos madagascariensis* (Species group AE, Table 4.1), *Ochna*

natalitia (Species group AF, Table 4.1), the shrub *Phyllanthus reticulatus* (Species group V, Table 4.1) and the grass *Panicum maximum* (Species group AM, Table 4.1). The degraded condition of this community was shown by the presence of exotics such as the grasses *Chloris gayana* (Species group G, Table 4.1) and *Sorghum halepense* (Species group H, Table 4.1) and the forbs *Ricinus communis* (Species group H, Table 4.1), *Ageratum houstonianum, Achyranthes aspera, Sesbania puncicea* (Species group I, Table 4.1), *Tagetes minuta,* (Species group K, Table 4.1), *Xanthium strumarium* (Species group V, Table 4.1) and *Lantana camara* (Species group AN, Table 4.1). *Sorghum halepense* (Species group H, Table 4.1) is an exotic, declared weed and a tall growing grass that stood out in this community. Red data species in this community were *Bridelia cathartica* (Species group S, Table 4.1) and *Gladiolus hollandii* (Species group AA, Table 4.1). Species of Species group H and I indicated an affinity between this community and the three other riparian woodlands (1, 2 and 3). Although there was an affinity between Communities 3 and 4, there was a higher occurrence of *Phragmites australis* (Species group I, Table 4.1) in community 3 and *Acacia sieberiana* (Species group E, Table 4.1) was not present in Community 4.

The average tree height in this community was 3m with 63% cover, shrub height was 1.1m with 31% cover, grass height was 85cm with 23% cover and forb height was 33cm with 29% cover (Table 4.4). An average number 51 species per relevé was recorded of which 9% were exotic, 1% was declared invaders and 5% were declared weeds (Table 4.5).

5 *Englerophytum magalismontanum -Sterculia murex* Woodland Community

The *Englerophytum magalismontanum–Sterculia murex* Woodlands Community was situated on the hills and slopes in Nelspruit. The slopes in this community were between 5-30° and were facing north to north-west. The soil form was Mispah and the soil surface had a rockiness that varied from 30 – 80%. Anthropogenic influences were low in these communities, except for relevé 45 that was highly disturbed. Relevé 45 was on a hill in the CBD, surrounded by industrial activities, a rugby field and a shopping centre. People slept on the hill and no facilities were available, therefore offensive odours and destruction of vegetation were quite obvious on this hill.

One of the differential species, *Englerophytum magalismontanum* (Species group J, Table 4.1), was also the dominant species in community. Other differential species included the tree *Acacia caffra,* the shrubs *Hippobromus paucifloris* and *Sphedamnocarpus pruriens* and the succulent *Sansevieria hyacinthiodes* (Species group J, Table 4.1). Other important tree species were *Ziziphus mucronata* (Species group M, Table 4.1), *Dombeya rotundifolia, Euclea natalensis* (Species group V, Table 4.1), *Combretum molle, Stercula murex* (Species group AE, Table 4.1), *Ochna natalitia* (Species group AF, Table 4.1) and *Diospyros lyciodes* (Species

group AJ, Table 4.1). Important shrub species included *Acacia ataxacantha* (Species group K, Table 4.1), *Bauhinia galpinii* (Species group AF, Table 4.1), *Dichrostachys cinerea* (Species group AK, Table 4.2), the declared invader *Lantana camara* (Species group AN, Table 4.1) and the native climber *Rhoicissus tridentata* (Species group AJ, Table 4.1). The important herbaceous species were the fern *Cheilanthus viridis* (Species group AK, Table 4.1) and the grass *Panicum maximum* (Species group AM, Table 4.1). Species group K (Table 4.1) indicated an affinity between community 5 and the riparian communities 1 to 4.

This community had 54% tree and shrub species, which was the highest number of tree and shrub species per community in the entire study area. Red Data species included trees such as *Combretum collinum* (Species group R, Table 4.1) and *Catha edulis* (Species that occur once, Table 4.2) and forbs such as *Gladiolus hollandii* (Species group AA, Table 4.1). Only a few declared weeds and declared invaders were recorded in this community. The most widespread declared weed in this community was *Lantana camara* (Species group AN, Table 4.1); some others were *Solanum seaforthianum* (Species group J, Table 4.1) and *Solanum mauritianum* (Species group K, Table 4.1).

This community had an average tree height of 6m with 62% cover, a shrub height of 1m with 33% cover, a grass height of 90cm with 17% cover and a forb height of 29cm with 29% cover (Table 4.4). An average number of 53 species was recorded per relevé of which 8% were exotic, 1% was declared invaders and 4% were declared weeds (Table 4.5).

6 *Pappea capensis – Panicum maximum* Woodland Community

This community was situated on the hills and in the lower-lying valley areas in Hazyview (350-500 masl, see figure 2.3). Most of the relevés were facing north or north-east with a slope of between 5–30°. The soil type was Glenrosa or sand with a surface rockiness between 0–75%. Some of the relevés were highly disturbed by grazing and trampling of cattle and goats as well as by the removal of plants by local residents for their daily lives such as for food (*Pappea capensis, Ziziphus mucronata, Diospyros mespiliformis*), crafts (*Berchemia zeyheri, Dalbergia melanoxylon*), shelter (*Bauhinia galpinii, Combretum apiculatum*), fuel (*Combretum hereroense, Dichrostachys cinerea*) and medicinal (*Heteropyxis natalensis*) uses. See Annexure B for more information on uses of plants for daily life.

The differential species in this community were the species in Species group L and included tree species such as *Pappea capensis* and *Combretum apiculatum* and forbs such as *Triumfetta rhomboidea* and *Stylochiton natalense* Other prominent species included *Sclerocarya birrea, Dombeya rotundifolia* and *Senna petersiana* (Species group V, Table 4.1), shrubs such as *Dichrostachys cinerea* (Species group AK, Table 4.1), and *Lantana camara*

(Species group AN, Table 4.1), herbaceous species such as the grass *Heteropogon contortus* (Species group AI, Table 4.1) and *Panicum maximum* (Species group AM, Table 4.1) and the fern *Cheilanthus viridis* (Species group AK, Table 4.1). Species that were recorded once with a low cover are listed in Table 4.2. *Combretum collinum* (Species group R, Table 4.1) and *Bridelia cathartica* (Species group S, Table 4.1) were Red Data species in this community.

Community 6 (Hills and valleys in Hazyview) could be distinguished from Community 5 (Hills and slopes in Nelspruit) in terms of the absence or low constancy of species in Species groups R, Y, and AI (Table 4.1) in Community 5. Species in Species group M (Table 4.1) indicated an affinity between this community and community 5.

This community had an average tree height of 3m with 48% cover, a shrub height of 1m with 29% cover, a grass height of 68cm with 38% cover and a forb height of 25cm with 16% cover (Table 4.4). An average number of 52 species was recorded per relevé of which 5% were exotic, 1% was declared invaders and 3% were declared weeds (Table 4.5). Several activities of the Working for Water program were apparent in this area. The Working for Water Programme (2001a) that is administrated by the Department of Water Affairs and Forestry cleared invasive alien plants. This initiative had a project in Hazyview (Working for Water Programme, 2001b), which is probably the reason for the low percentage of exotic declared invaders and weeds in this community.

7 *Terminalia sericea – Agathisanthemum bojeri* sub sp *bojeri* Woodland Community

This community had sandy soil and was situated in valleys (slope 5-10°) as well as areas with a gentle slope (10-15°) in Hazyview. Trees were stunted because of cutting and burning in some areas. Sand mining also took place for brick making and no rehabilitation was done.

Differential species were species in Species group N (Table 4.1) and include trees such as *Terminalia sericea* (also the dominant species), shrub species such as *Euclea divinorum,* and forbs such as *Agathisanthemum bojeri* sub sp *bojeri, Sida cordifolia* and *Jasminum fluminense.* Other prominent species included a tree species *Annona senegalensis* (Species group AJ, Table 4.1), shrub species such as *Dichrostachys cinerea* (Species group AK, Table 4.1) and *Lantana camara* (Species group AN, Table 4.1), forb species such as *Kohautia virgata* (Species group Y, Table 4.1), *Waltheria indica* (Species group AI, Table 4.1) and *Richardia brasiliensis* (Species group AK, Table 4.1) and grass species such as *Perotis patens* (Species group Y, Table 4.1), *Aristida congesta, Heteropogon concortus, Pogonarthria squarrosa* (Species group AI, Table 4.1) and *Melinis repens* (Species group AJ, Table 4.1).

This community had an average tree height of 3m with 62% cover, shrub height of 1m with 14% cover, grass height of 63cm with 47% cover and forb height of 32cm with 18% cover (Table 4.4). An average number of 60 species was recorded per relevé of which 3% were exotic and 3% were declared weeds (Table 4.5). Although destruction of vegetation was visible, this community had the highest number of species per sampling plot (60) and no declared invaders, probably because of the Working for Water project in the Hazyview area (Working for Water Programme, 2001b).

Two sub-communities were distinguished based upon topography, aspect and anthropogenic influences. Subcommunity 7.1 was situated in valleys in open spaces further away from residential areas and subcommunity 7.2 was situated on rocky outcrops close to residential areas. Overgrazing and sand mining was a huge problem in both communities. Subcommunity 7.1 could be distinguished from Community 7.2 with regard to the presence of species in Species group O - S and the absence of species in Species group T in community 7.1.

7.1 *Antidesma venosum–Terminalia sericea* Woodland Subcommunity

The *Antidesma venosum - Terminalia sericea* Woodland Subcommunity was situated in the northern residential areas of Planning Area A2, Tshabalala and Nyongani. Although these open spaces were further away from the residential areas, some areas were severely destructed.

Differential species were those in species group O (Table 4.1) and included tree species such as *Antidesma venosum* (also dominant species), *Heteropyxis natalensis* and *Ximenia caffra*. Other prominent species included tree species such as *Pavetta shumanniana* (Species group U, Table 4.1), *Sclerocarya birrea, Phyllanthus reticulatus* (Species group V, Table 4.1), *Anonna senegalensis* (Species group AJ, Table 4.1) and *Dichrostachys cinerea* (Species group AK, Table 4.1) Herbaceous species included *Perotis patens, Kohautia virgata* (Species group Y, Table 4.1), *Helichrysum kraussii* (Species group AH, Table 4.1), *Aristida congesta, Heteropogon concortus, Waltheria indica, Pogonarthria squarrosa, Eragrostis curvula* I,4.1 *Melinis repens* (Species group AJ, Table 4.1) and *Richardia brasiliensis (*Species group AK, *Table 4.1).* Red data species included *Combretum collinum* (Species group R, Table 4.1) and *Bridelia cathartica* (Species group S, Table 4.1). *Lantana camara* (Species group AN, Table 4.1) and exotic species is *Bidens pilosa* (Species Group AM, Table 4.1) was the declared weed species in this community.

Community 7.1 was further characterized with the affinity between Communities 7.1 and 6 with the presence of species in Species group R (Table 4.1) and between Communities 4, 5 and 6 with the presence of species in Species group S.

The average tree height in this community was 2m with a 57% cover, the shrub height was 1m with 25% cover, the grass height was 64cm with a cover of 55% and the forb height was 36cm with 27% cover (Table 4.4). An average number of 63 species per relevé was recorded (the highest of all communities) of which 2% were exotic, declared weeds (Table 4.5).

Two variants that were interconnected with each other could be distinguished in the *Antidesma venosum–Terminalia sericea* Subcommunity, namely the 7.1.1 *Gerbera aurantiaca* variant and 7.1.2 *Waltheria indica* variant. Variant 7.1.1 could be distinguished from variant 7.1.2 regarding the presence of species in Species Group P and the absence of species in Species Group Q. Variant 7.1.1 could be further distinguished from variant 7.1.2 with respect to the occurrence of taller trees (3m) with less cover (46%) than variant 7.1.2 (tree height - 2m, cover - 65%). *Dichrostachys cinerea* (Species Group AK, Table 4.1) had a higher cover in variant 7.1.1 than in variant 7.1.2, while *Lantana camara* (Species Group AN, Table 4.1) had a higher cover in variant 7.1.2. *Dichrostachys cinerea* could be a serious encroacher if veld is mismanaged (Schmidt *et al.*, 2002) and *Lantana camara* is an exotic, category 1, declared weed (Henderson, 2001).

7.1.1 *Gerbera aurantiaca* Woodland variant

The *Gerbera aurantiaca* Woodland variant occurred in valley areas with a 5° slope, facing north. Differential species were species in species Group P and included forbs such as *Gerbera aurantiaca, Kyllinga erecta* and *Ocimum americanum* var *americanum.* Other prominent species included trees such as *Annona senegalensis* (Species Group AJ, Table 4.1) and *Dichrostachys cinerea,* also the dominant species, (Species Group AK, Table 4.1), forbs such as *Phyllanthus parvulus, Helichrysum kraussii* (Species Group AH, Table 4.1), *Waltheria indica* (Species Group AI, Table 4.1), and *Cheilanthes viridis* (Species Group AK, Table 4.1), grass species such as *Digitaria diagonalis* (Species Group P, Table 4.1), *Perotis patens* (Species Group Y, Table 4.1), *Eragrostis biflora* (Species Group AE, Table 4.1), *Heteropogon contortus*, *Pogonarthria squarrosa* (Species Group AI, Table 4.1) and *Melinis repens* (Species Group AJ, Table 4.1).

The average tree height in this community was 3m with 46% cover, shrub height was 1.5m with 32% cover, grass height werase 70cm with 49% cover and forb height was 43cm with 28% cover (Table 4.4). An average number of 63 species per relevé was recorded of which 5% were exotic and <1% were declared weeds (Table 4.5).

7.1.2 *Waltheria indica* Woodland variant

The *Waltheria indica* Woodland variant occurred in areas with a gentle slope of 10-25°. The differential species were species in Species Group Q and included prominent tree species such

as *Piliostigma thonningii, Rhus leptodictya, Parinari curatellifolia, Rhus rehmanniana, Dalbergia melanoxylon*, (Species Group Q, Table 4.1), *Pavetta schumanniana,* Sclerocarya birrea (Species Group V, Table 4.1), *Anonna senegalensis* (Species Group AJ, Table 4.1), *Dichrostachys cinerea* (Species Group AK, Table 4.1), shrubs such as *Gymnosporia heterophylla* (Species Group U, Table 4.1), *Lantana camara* (Species Group AN, Table 4.1), forbs such as *Geigeria burkei* (Species Group Q, Table 4.1), *Waltheria indica,* also the dominant species (Species Group AI, Table 4.1), grass species such as *Aristida congesta, Heteropogon contortus* (Species Group AI, Table 4.1) and *Melinis repens* (Species Group AJ, Table 4.1). Variant 7.1.2 was further characterized with respect to affinities with Community 6 and Variant 7.1.1 with the presence of species in Species Group R, as well as with Communities 4 to 6 and Variant 7.1.1 with the presence of species in Species Group S.

The average tree height in this community was 2m with 65% cover, the shrub height was 0.7m with 20% cover, the grass height was 60cm with a cover of 60% and the forb height was 33cm with 26% cover (Table 4.4). An average number of 63 species per relevé was recorded of which 5% were exotic and <1% were declared weeds (Table 4.5).

7.2 *Combretum molle – Dichrostachys cinerea* Woodlands Subcommunity

The *Combretum molle – Dichrostachys cinerea* Woodlands Subcommunity was mostly situated in the southern residential area, Nkambeni, of planning precinct A2, with one relevé in Nyongani, the north-eastern residential area. The soil was sandy with no surface rocks and had a slope of 5-15°.

Although the differential species in this subcommunity were the species in Species group T, this subcommunity was better characterized by the absence of species in species group O to S and the higher abundance of the tree species *Combretum molle* (Species group AE, Table 4.1), *Peltophorum africana* (Species Group AF, Table 4.1) and *Dichrostachys cinerea* (Species group AK, Table 4.1). Other prominent species included shrubs such as *Lantana camara* (Species group AN, Table 4.1) and grass species such as *Aristida congesta* (Species group AI, Table 4.1) and *Panicum maximum* (Species group AM, Table 4.1).

Subcommunity 7.2 differed from subcommunity 7.1 with respect to the absence of species in Species Groups O-S. Affinities between Subcommunities and Communities 7.2, 7.1, 6 and 5 were identified by species in Species Group U, and between Subcommunities and Communities 7.2 and 4, 5, 6 and 7.1 were identified by species in Species Group V. Red data species included *Combretum collinum* (Species group R, Table 4.1). Problem species included declared weeds such as *Xanthium strumarium* (Species Group V, Table 4.1), *Lantana camara*

(Species Group AN Table 4.1) and exotic species included *Bidens pilosa* (Species Group AM, Table 4.1).

The average tree height in this community was 4m with 66% cover, shrub height was 0.33m with 3% cover, grass height was 63cm with 39% cover and forb height was 28cm with 9% cover (Table 4.4). An average number of 55 species per relevé was recorded, of which 4% were exotic and <1% were declared invaders and 3% were declared weeds (Table 4.5).

8 *Cyanotis speciosa – Selaginella dregei* Herbaceous Open Woodland Community on exposed granite outcrops.

The *Cyanotis speciosa – Selaginella dregei* Herbaceous Open Woodland Community on exposed granite outcrops occurred in soil pockets on solid granite rock in the northern residential area, Tshabalala, of Planning Area A2. The soil type varied from shallow washed down sandy-loam with no surface rocks to a Mispah soil form with a surface rockiness of 25%. Anthropogenic influences were high in this community because it connected residential areas to each other and served as foot paths for cattle that graze freely.

The differential species in this subcommunity were the species in Species group W, but this community was further characterized by the presence of species in Species group AD (Table 4.1) that included forbs such as *Cyanotis speciosa* and *Selaginella dregei*, also the dominant species.

The average tree height in this community was 0,5m with 13% cover, shrub height was 0.3m with 16% cover, grass height was 53cm with 17% cover and forb height was 32cm with 37% cover (Table 4.4). Species regarded as trees and shrubs in this community were represented by saplings because of the shallow washed down sandy-loam soil. An average number of 32 species per relevé was recorded, of which 2% were declared weeds and 5% were exotic plants (Table 4.5).

Three variants could be distinguished in the *Cyanotis speciosa – Selaginella dregei* Community, each only represented by one relevé. The first variant, 8.1 *Bulbostylis hispidula* variant (Relevé 1), had no differential species but had dominant species such as *Coleochloea setifera* (Species Group X, Table 4.1) and *Perotis patens* (Species Group Y, Table 4.1).

Variant 8.1 had an average shrub height of 0.2m with 2% cover, grass height of 30cm with 40% cover and forb height of 30cm with 60% cover (Table 4.4). An average number of 31 species per relevé was recorded of which 3% were exotic (Table 4.5). Parts of the *Coleochloa setifera – Aloe petricola* short sparse shrub land described by Deal (1985) are similar to this community.

Variant 8.2 *Cyperus rupestris* (Relevé 8) had no differential species but had dominant species such as *Aristida congesta* and *Rhoicissus tridentata.* Variant 8.1 could be distinguished from variant 8.2 with respect to the absence of species in species group W, and variant 8.1 had an affinity with variant 8.2 with the presence of species in Species Groups W and Y.

Variant 8.2 had an average tree height of 1.5m with 40% cover, a shrub height of 0.5m with 20% cover, a grass height of 50cm with 10% cover and a forb height of 30cm with 5% cover (Table 4.4). An average number of 55 species per relevé was recorded of which 7% were exotic and 4% were declared weed (Table 4.5).

The differential species of the third variant, 8.3 *Myrothamnus flabellifolius* (Relevé 2), were species in Species Group Z with dominant species such as *Bulbostylis hispidula* (Species Group W, Table 4.1) and *Myrothamnus flabellifolius* (Species Group Z, Table 4.1). Variant 8.3 was distinguished from variant 8.1 and 8.2 with respect to the absence of species in Species Groups X and Y (Table 4.1) and had an affinity with variant 8.1 with the presence of species in Species Group W (Table 4.1

Variant 8.3 had an average shrub height of 0.3m with 25% cover, grass height of 80cm with 1% cover and forb height of 35cm with 45% cover (Table 4.4). An average number of nine species per relevé was recorded with no exotics, declared weeds or declared invaders (Table 4.5).

9 *Xerophyta retinervis – Combretum molle* Herbaceous Open Woodland Community on exposed granite outcrops.

This community occurred in soil pockets in Nelspruit that occurred on top of exposed granite outcrops or on hills with gentle (10-20°) to steep (20-35°) slopes. The soil varied from sand to the soil form Mispah that had a surface rockiness of 5-80%.

Differential species were species in Species group AA and included indigenous shrubs such as *Xerophyta retinervis* and *Asclepias* species and forbs such as *Commelina africana, Hypoxis rigidula, Pearsonia* species, *Pellaea calomelanos, Oldenlandia herbacea* and the red data species *Gladiolus hollandii.* Other prominent species included tree species such as *Combretum molle, Strychnos madagascariensis* and *Sterculia murex* (Species group AE, Table 4.1), forb species such as *Cyperus rupesteris*, (Species group AD, Table 4.1), *Polygala uncinata* (Species group AE Table 4.1) and *Cheilanthes viridus* (Species group AK, Table 4.1) and grass species such as *Aristida congesta* (Species group AI, Table 4.1), *Melinis repens, Loudetia simplex* (Species group AJ, Table 4.1) and *Hyparrhenia hirta* (Species group AM, Table 4.1).

This community had an average tree height of 3m with 30% cover, shrub height of 1m with 18% cover, grass height of 82cm with 38% cover and forb height of 37cm with 42% cover (Table 4.4). An average number of 46 species was recorded per sample plot of which 3% were exotics and 2% were declared weeds (Table 4.5).

The Nelspruit dome community (9) had fewer anthropogenic impacts, deeper soil and the pocket surfaces were larger than in the dome community of Hazyview (8). The species richness was also higher in Nelspruit than in Hazyview (42 vs 32). Exposed granite outcrops in Nelspruit had a higher percentage tree cover (30% vs 10%) and the trees were higher in Nelspruit than in Hazyview (3m vs 1.5m) (Table 4.4). Although there were differences between communities 8 and 9, species in Species group AD (Table 4.1) indicated an affinity between these communities. Species in Species Groups AE and AF included affinities between other communities (4-8) (Table 4.1).

Two subcommunities were distinguished in the *Xerophyta retinervis – Combretum molle* Community, based on species composition, environmental factors and human impacts. Subcommunity 9.1 occurred on slopes with a northern or western aspect of 10-20° whereas Subcommunity 9.2 had a southern or western aspect with a steeper slope (20-35°). Subcommunity 9.1 was more accessible for people staying in the area, like relevé 46 which is close to a church. Although community 9.2 was not that accessible, the relevé formed part of a newly built residential area.

9.1 *Polygala uncinata – Xerophyta retinervis* Herbaceous Open Woodland Subcommunity on exposed granite outcrops.

This subcommunity was situated on the northern or western aspects of hills in Nelspruit with slopes of 10-20°. The soil was sandy with a rockiness of 60-80%. Differential species were species from Species group AB that included forbs such as *Tephrosia elongata, Cyperus rotundus, Euophorbia prostata* and grass species such as *Hyparrhenia tamba and Brachiaria brizantha.* Other prominent species were *Xerophyta retinervis, Hypoxis rigidula* (Species group AA, Table 4.1), *Cyperus rupestris* (Species group AD, Table 4.1), *Combretum molle, Polygala uncinata* (Species group AE Table 4.1), *Loudetia simplex* (Species group AJ, Table 4.1), also the dominant species, and *Cheilanthes viridus* (Species group AK, Table 4.1).

This community had an average tree height of 3m with 14% cover, shrub height of 1m with 22% cover, grass height of 90cm with 43% cover and forb height of 43cm with 43% cover (Table 4.4). An average number of 47 species was recorded per sample plot of which 2% were exotics and declared weeds (Table 4.5).

9.2 *Strychnos spinosa – Hyparrhenia hirta* Herbaceous Open Woodland Subcommunity on exposed granite outcrops.

The *Strychnos spinosa – Hyparrhenia hirta* Herbaceous Open Woodland Subcommunity on exposed granite outcrops occurred on hills in Nelspruit and was situated on the southern and western aspects with slopes of 20-35°. The soil form was Mispah with a surface rockiness of 70%. Differential species were species in Species group AC that included tree species such as *Strychnos spinosa* and shrubs such as *Elephantorrhiza* sp. and *Jatropha curcas.* (Species Group AL, Table 4.1). The dominant species were *Loudetia simplex* (Species group AH, Table 4.1) and co-dominant species were *Hyparrhenia hirta* (Species group AK, Table 4.1). Other prominent species included species such as *Lannea discolor* (Species group AH, Table 4.1), *Cheilanthes viridus* (Species group AI, Table 4.1), *Bidens pilosa* (Species group AK, Table 4.1), *Lantana camara* (Species group AL, Table 4.1), *Selaginella dregei* (Species group AB, Table 4.1) and *Pogonarthria squarrosa* (Species group AG, Table 4.1).

Subcommunity 9.2 can be distinguished from Subcommunity 9.1 with respect to the absence of species in Species Group AB. Affinities between Subcommunity 9.1, 9.2 and Community 8 were identified by species in Species Group AD, those between Subcommunities 9.1, 9.2 and Communities 5-9 by species in Species Group AE and those between Subcommunities 9.1, 9.2 and Communities 4-9 by species in Species Group AF. Species in Species Group AB were mainly forbs and grasses, while Species Group AC included trees, shrubs and forbs (Table 4.1).

This community had an average tree height of 2m with 47% cover, shrub height of 1m with 13% cover, grass height of 73cm with 33% cover and forb height of 30cm with 40% cover (Table 4.4). An average number of 45 species was recorded per relevé of which 4% were exotics and 2% were declared weeds (Table 4.5).

10 *Lannea edulis – Hyparrhenia hirta* Grassland Community

This community occurred on the top of hills or in lower lying areas between the hills. The soil form was Mispah, with a rockiness of between 10-70%.

The differential species included species in Species Group AG, such as *Lannea edulis, Veronica barbatonitis, Sebaea grandis, Felicia mossamedensis, Bothriochloa insculpta, Corchorus asplenifolius* and *Berkheya setifera.* The dominant species was *Lantana camara* (Species group AN, Table 4.1). Other prominent species included *Helichrysum kraussii* (Species group AH, Table 4.1), *Themeda triandra* (Species group AJ, Table 4.1) and *Hyparrhenia hirta* (Species group AM, Table 4.1). Community 10 had affinities with communities indicated by species in Species Group AH – AK (Table 4.1).

This community had an average tree height of 5m with 13% cover, shrub height of 1m with 13% cover, grass height of 123cm with 70% cover and forb height of 31cm with 23% cover (Table 4.4). An average number 47 species per relevé was recorded of which 3% were exotics, 1% was declared invaders and 3% were declared weeds (Table 4.5).

Table 4.4: The average percentage cover and height of the different strata in the plant communities of open spaces in Hazyview and Nelspruit, Mbombela.

Community/Sub Nr	Tree Height (m)	Tree cover (%)	Shrub Height (m)	Shrub cover (%)	Grass Height (cm)	Grass cover (%)	Forb Height (cm)	Forb cover (%)
1	7	42	1.7	25	44	40	26	30
1.1	4	31	1.5	21	60	60	40	50
1.2	▲ 10	52	▲ 1.9	30	■ 28	20	■ 13	10
2	6	23	1	10	55	10	▲ 50	40
3	6	30	1.2	15	90	6	38	57
4	3	63	1.1	31	85	23	33	29
5	6	62	1	▲ 33	90	17	29	29
6	3	48	1	29	68	38	25	16
7	3	62	1	14	63	47	32	18
7.1	2	57	1	25	64	55	36	27
7.1.1	3	46	1.5	32	70	49	43	28
7.1.2	1.9	65	0.7	20	60	60	33	26
7.2	4	▲ 66	0.33	3	63	39	28	9
8	0.5	13	0.3	18	53	13	33	39
8.1	■ 0	■ 0	■ 0.2	■ 2	30	40	30	▲ 60
8.2	1.5	40	0.5	20	50	10	30	■ 5
8.3	■ 0	■ 0	0.3	25	80	■ 1	35	45
9	3	30	1	18	82	38	37	42
9.1	3	14	1	22	90	43	43	43
9.2	2	47	1	13	73	33	30	40
10	5	13	1	13	▲ 123	▲ 70	31	23

▲ Highest value of all communities for a specific stratum. ■ Lowest value of all communities for a specific stratum.

Table 4.5: List of average species per relevé for each plant community and percentage of exotics, declared invaders and weeds of open spaces in Hazyview and Nelspruit, Mbombela.

Community or Subcommunity No	Average Species / community	Exotic Species (%)	Declared invaders (%)	Declared Weeds (%)
1	34	23	4	11
1.1	33	25	3	17
1.2	36	21	6	6
2	36	▲ 31	▲ 13	17
3	32	26	4	▲ 18
4	51	9	1	5
5	53	8	1	4
6	52	5	1	3
7	60	3	< 1	3
7.1	▲ 63	2	<1	2
7.1.1	63	5	<1	1
7.1.2	63	5	<1	1
7.2	55	4	<1	3
8	32	5	■ 0	2
8.1	31	3	■ 0	■ 0
8.2	55	7	4	■ 0
8.3	■ 9	■ 0	■ 0	■ 0
9	46	3	■ 0	2
9.1	47	2	■ 0	2
9.2	45	4	■ 0	2
10	47	3	1	3

▲ Highest value of all communities for a specific stratum. ■ Lowest value of all communities for a specific stratum.

4.4 Ordinations

4.4.1 DCA-ordination

The distribution of relevés along the first and second axes of ordination is presented in Figure 4.2. Relevés 1, 2 and 21 were excluded from this ordination because they were outliers. The following four vegetation units could be identified in this diagram: A: Riparian/Wetlands vegetation, B: Grasslands, C: Open Woodlands on exposed granite outcrops and D: Woodlands on hills and in valleys of Hazyview and Nelspruit. This diagram illustrated a gradient on ordination axis 1 which could be related to the wetness of the soil from high on the left to low on the right, and soil depth with deeper soil on the left and shallower, rocky soil on the right. The gradient could also be related to the degree of disturbance of the vegetation caused by the land use bordering the open spaces as well as grazing and trampling by animals. It also illustrated the amount of exotic species in the different communities, where Group A, which included the riparian vegetation in Nelspruit (communities 1, 2 and 3), had more exotic species (on the left) than Group D, which included the slopes and valleys of Hazyview (communities 6 and 7), on the right. The gradient along ordination axis 2 could be related to altitude. The communities of group C included the summits and exposed granite outcrops of Nelspruit that are situate at higher altitudes, while the communities of group D included the slopes and valleys of Hazyview at lower altitudes.

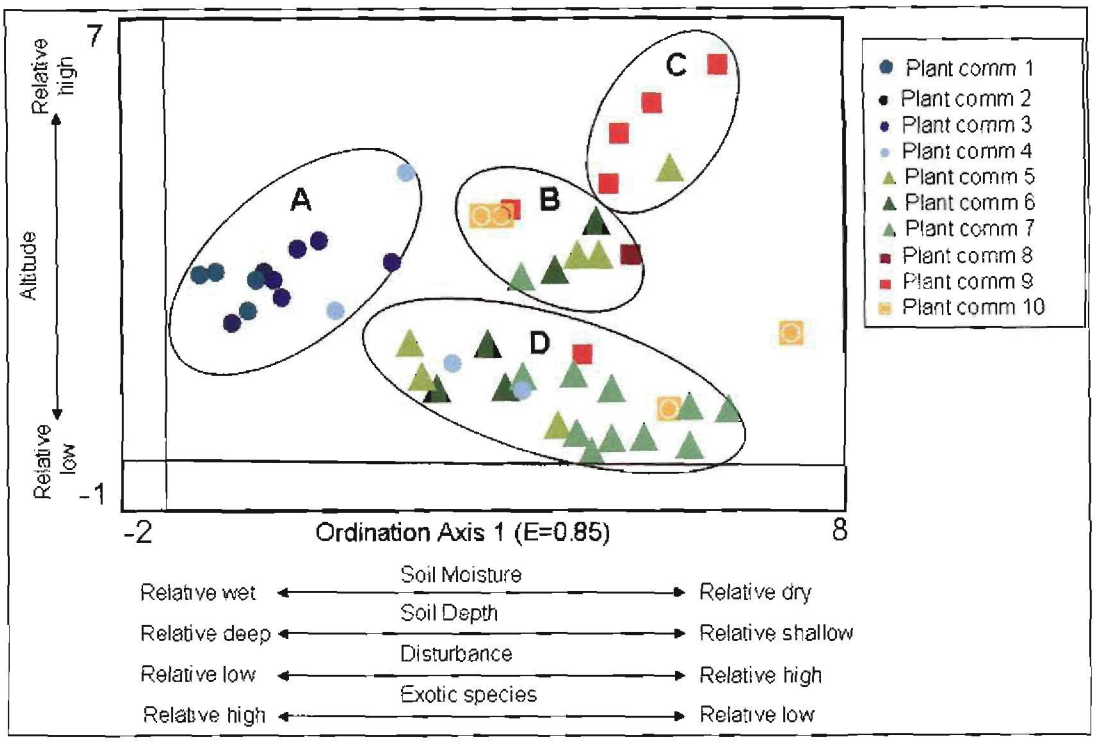


Figure 4.2: The relative position of the Plant Communities along the first two axes of a DCA-ordination of floristic data of natural open spaces in Hazyview and Nelspruit, Mbombela.

4.5 Conclusion

Ten plant communities, four subcommunities and five variants were described in the two studied planning areas in the natural open spaces of Nelspruit and Hazyview. No previous vegetation study was completed for these areas on this specific scale, so no similar plant communities had been described in other studies. Deal (1985) described the vegetation along a broad transect within the floristic region associated with the Sabie area, which included the area from Sabie to Hazyview, using transects in four parts namely Sub-humid mistbelt, Humid mistbelt, Transitional mistbelt and Low Country. Low Country was divided in the Upper foothills and Lower foothills of which Hazyview forms a part. According to the description of Deal (1985,) the Low Country's Ecological formation class is Woodland and Xeric thicket, which is divided in three vegetation types namely Partially sheltered Woodland and Thicket on fairly shallow soils of the Lower foothills, Less-sheltered Woodland and Thicket on fairly deep soils of the Upper Foothills and the Woodland and Shrub land on exposed granite outcrops. Deal (1985) described several plant communities in this area, of which a few were similar to communities described in this current study.

This current study found more exotic plants, declared invaders and weeds in rivers and streams (Table 4.5) in plant communities 1, 2 and 3 in Nelspruit, in contrast with the riparian areas of

Hazyview that had a low percentage of exotic plants, declared invaders and weeds in rivers and streams (Table 4.5). Roberts and Poynton (1985) stated that there is a tendency to favour exotic plants in central urban open spaces in South Africa and it is important to incorporate mitigation measures into the planning and management of urban planning policies to stop the spread of exotic species. The formulation of planning policies incorporated with research data like this study and others on planning scale is a feature for Mbombela Local Municipality.

The ten described plant communities can be clearly grouped into four units, as indicated by the dendogram in Figure 4.1, and to a certain extent by the DCA-ordination in Figure 4.2. For the purpose of this study and further applications, each one of these units can be regarded as a specific biotope within the major natural open spaces biotope type:

1) Riparian Woodlands with rivers, streams and disturbed streams (Communities 1, 2, 3 and 4) (referred to as rivers and streams).
2) Woodlands on hills and in valleys (Communities 5, 6 and 7) (referred to as hills and valleys)
3) Herbaceous Open Woodlands on exposed granite outcrops (Communities 8 and 9) (referred to as granite outcrops)
4) Grasslands (Community 10) (referred to as grasslands).

CHAPTER 5



Bird survey and Carbon storage

CHAPTER 5
BIRD SURVEY AND CARBON STORAGE

5.1 Introduction

Increasing urbanization will convert land cover (Zipperer *et al.*, 2000) and will have a direct or indirect effect on the environment (Sandström *et al.*, 2006). To maintain long-term sustainability, an ecological approach to land use planning is essential (Zipperer *et al.*, 2000). For sustainable urban development, it is important to maintain green open spaces as a functional network to mitigate negative impacts (Sandström *et al.*, 2006). Green open spaces in urban areas are important for avifauna (White *et al.*, 2005), vegetation (Wood, 1994; Cilliers & Bredenkamp, 2000; Sukopp & Weiler, 1988), biodiversity (Godefroid, 2001; Alvey, 2006), recreation (Niemelä, 1999), climate (Akbari, 2002; Gomez *et al*, 1998) as well as health improvement (Jackson, 2002; Chiesura, 2004; Nowak, 2006; Nowak *et al.*, 2006). Species diversity is useful to demonstrate functionality, as it is dependent on a representative and sufficiently connected network of habitats (Sandström *et al.*, 2006).

In this chapter the total number of birds, total number of bird species and carbon storage values in different plant communities and biotopes were compared. The patterns of bird diversity in different areas were not investigated in this study. A literature study on the contribution of tree height and percentage tree cover towards the determination of carbon storage in the different plant communities and biotopes of the two study areas is included in this chapter.

5.2 Bird survey

5.2.1 Introduction

Birds are easily monitored by skilled observers and provide a mechanism to explore urban effects and responses to different urban designs (Chace & Walsh, 2006). Chace and Walsh (2006) also stated that factors such as the presence and patch size of vegetation, competition with exotic species, non-native predators, the structure and floristic attributes of vegetation, supplementary feeding by humans and residual pesticides determine which bird species can co-exist within human settlements. Smith (2004) found that there is a decline in avian diversity and an increase in biomass of birds in urban areas as resources diminish at high levels of urbanization in commercial and business districts, while Jokimäki (1999) explained that factors other than natural areas can affect the distribution of some bird species in urban parks. Because of the correlation between the volume and structure of vegetation and bird diversity and species richness (Chace & Walsh, 2006), detailed ecological analysis of urbanisation processes are needed for successful management of urban bird populations (Vuorisalo *et. al.*, 2003). Investigation of human impacts on natural areas can be used as a basis for planning

and development of further sustainable landscapes in urban areas (Mander & Jongman, 1998). Studies on bird richness were done in Nelspruit by Lawson (2001), but have to be incorporated in the urban planning policies for a holistic approach in the studying of landscape changes (Mander & Jongman, 1998).

Smith (2004) found the greatest number of species in areas where the necessary food, water and nesting material were available. The greatest number of birds in Potchefstroom was in the industrial and the residential areas close to the industrial area. Natural and agricultural areas and the Prozesky bird sanctuary in Potchefstroom had higher bird diversity. Water supply was important for nesting sites of water birds in areas with agricultural activities and the Prozesky sanctuary, a wetland. Generalists had the highest occurrence in residential areas where they were able to utilise most of the available resources. Green spaces had the greatest diversity (highest mean number of species) of birds. Smith (2004) stated that natural open spaces in urban areas improve quality of life and that it is important to maintain requirements of various wildlife species to maintain quality of life. The understanding of bird ecology could help sustain bird populations in urban areas and ecologists would be able to develop solutions compatible with human uses (Smith, 2004).

This study focused on bird richness and the association of nesting and feeding guilds with plant structures. The association of bird species richness, nesting and feeding guilds with plant structure in the different plant communities is discussed first, after which the associations in the different biotopes are discussed.

The aim of the bird study within the natural open spaces of the two monitored areas in Mbombela was to compare the different plant communities and biotopes with respect to:

- The total number of birds and the total number of bird species in the different plant communities and biotopes,
- the diversity of nesting and feeding guilds, and
- to determine the relation of total number of birds and total number of species per sampling point and nesting and feeding guilds with tree cover and tree height in the different plant communities and biotopes.

5.2.2 Results and discussion

The classification of the ten plant communities, according to the phytosociological table (Table 4.1), in Planning Areas A and H have been used for the bird study. A brief summary of the plant communities, type of open space and dominant plant structural type, as described in Chapter 4, are given in Table 5.1 for Planning Area A (Hazyview) and in Table 5.2 for Planning Area H (Nelspruit). A list of birds with feeding and nesting guilds is given in Annexure C.

The survey method of the birds in the study areas is described in Chapter 3 and the sampling points are indicated in Figure 3.3 for Planning Area A and Figure 3.5 for Planning Area H. The identification of birds were done according to Hockey *et al.* (2006); Sinclair *et al.* (2002) and Oberprieler (2001), while the feeding and nesting guilds were determined according to Hockey *et al.* (2006); Smith (2004) and Tarboton (2001).

Table 5.1: A summary of the description of plant communities in Planning Area A (Hazyview)

Plant community no	Biotope	Plant community description	Dominant plant structural type
4	Rivers and streams	*Pouzolzia mixta-Bauhinia galpinii* Riparian Woodland	Tree / Forb
6	Hills and valleys	*Pappea capensis-Panicum maximum* Woodland	Trees / grass
7	Hills and valleys	*Terminalia sericea–Agathisanthemum bojeri* Woodland	Stunted trees
8	Granite outcrops	*Cyanotis speciosa–Selaginella dregei* Herbaceous Open Woodland on exposed granite outcrops	Forb

Table 5.2: A summary of the description of plant communities in Planning Area H (Nelspruit).

Plant community nr	Biotope	Plant community description	Dominant plant structural type
1	Rivers and streams	*Syzygium cordatum–Breonadia salicina* Riparian Woodland	Trees
2	Rivers and streams	*Ficus sur–Tecoma stans* Riparian Woodland	Trees
3	Rivers and streams	*Amaranthus hybridus–Acacia sieberiana* Riparian Woodland	Trees / Reeds
5	Hills and valleys	*Englerophytum magalismontanum-Sterculia murex* Woodland	Trees
9	Granite outcrops	*Xerophyta retinervis–Combretum molle* Herbaceous Open Woodland on exposed granite outcrops	Shrubs
10	Grasslands	*Lannea edulis–Hyparrhenia hirta* Grassland	Grass

5.2.2.1 Bird numbers, species numbers, feeding and nesting guilds associated with tree cover and height structure in Planning Area A (Hazyview)

The bird species most recorded in the different plant communities of Planning Area A were the Black-eyed Bulbul (20), European Swallow (16), Yellow-eyed Canary (12), Cattle Egret (7),

Emerald-spotted Dove (7) and the Purple-crested Turaco (7). It was only the yellow-eyed Canary and the Emerald-spotted Dove that was not present in all four plant communities of Planning Area A (Table 5.3).

Table 5.3: Most represented birds in the different plant communities of Planning Area A.

Common name of birds	Roberts No	Total no birds / Plant comm	Plant comm 4	Plant comm 6	Plant comm 7	Plant comm 8
Black-eyed Bulbul	566	20	4	4	5	7
European Swallow	518	16	2	5	7	2
Yellow-eyed Canary	869	12	3	3	6	0
Cattle Egret	71	7	1	2	3	1
Emerald-spotted Dove	359	7	0	2	3	2
Purple-crested Turaco	371	7	1	2	3	1

In Planning Area A the highest number of birds (110) and the highest number of bird species (52) were recorded in plant community 7 (Table 5.4 and Figure 5.1). Plant Community 7 was situated in the hills and valleys of the Hazyview area, with dominant tree species such as stunted *Terminalia sericea* and forb species such as *Agathisanthemum bojeri* (Table 5.1). The average tree height in Plant Community 7 was 3m with 62% cover (Table 4.4). Although Plant Community 4 also had a tree height of 3m and 63% tree cover, Plant Community 7 had the highest number (60) of plant species per community (Table 4.5) while Plant Community 4 had a grass cover of 47%, the highest grass cover in Planning Area A (Table 4.4). These differences in plant species richness could contribute to the fact that more birds and bird species were observed in Plant Community 7 than in Plant Community 4.

Plant Community 8 had the lowest recorded number of birds (31) and the lowest number of bird species (25) (Table 5.4 and Figure 5.1). Plant Community 8 was situated on exposed granite outcrops of Hazyview and had 32 plant species (Table 4.5), with dominant forbs such as *Cyanotis speciosa* and *Selaginella dregei* (Table 5.1). The forb stratum was 33cm high and had a cover of 39%. The average tree height of Plant Community 8 was 0.5m with 13% tree cover (Table 4.4). The higher human impact and the low tree cover and height than in the other plant communities could contribute to the low number of birds recorded.

Table 5.4: Number of birds and bird species observed and plant structure (tree height and cover) in different plant communities of Planning Area A

Plant communities	4	6	7	8
Total number of birds	48	56	110	31
Total number of bird species	37	38	52	25
Tree Height (m)	3	3	3	0.5
Tree cover (%)	63	48	62	13

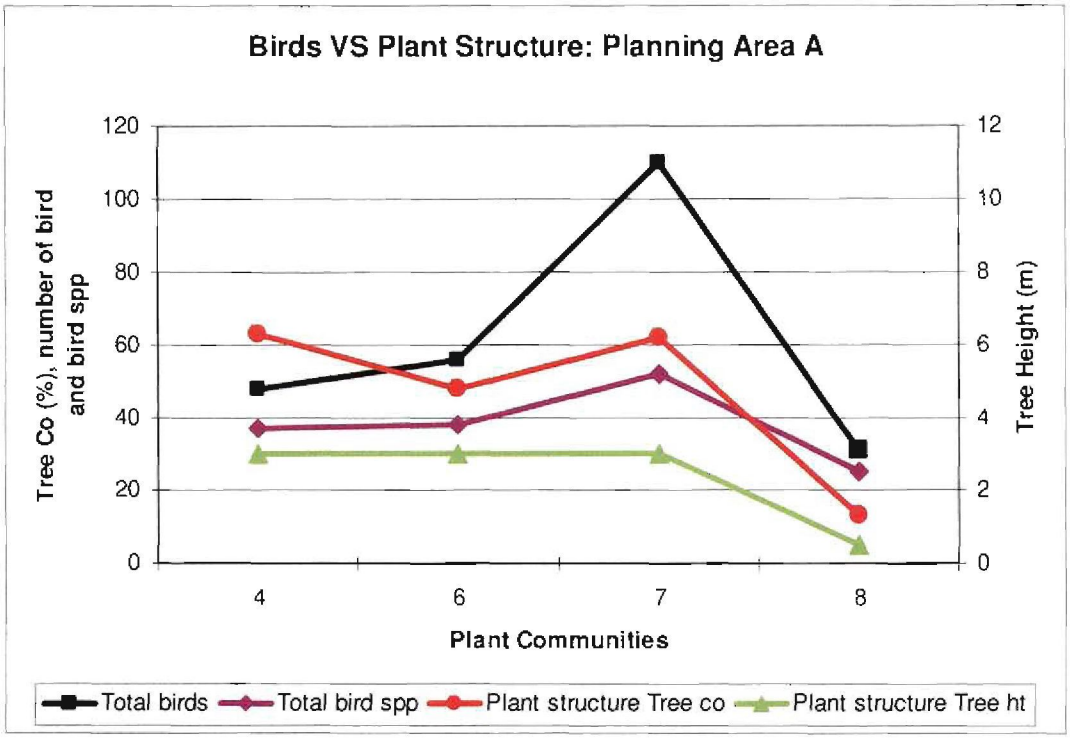


Figure 5.1: The relation between the numbers of birds (Total birds), number of bird species (Total bird spp), % Tree cover (Tree co) and Tree height (Tree ht) in the different plant communities of Planning Area A (Plant Communities 4, 6, 7 & 8)

The method used in the feeding guild study following Smith (2004) was discussed in Chapter 3. The investigation focused on the feeding guild richness and the most represented feeding guilds of the birds in the different plant communities of Planning Area A. The plant community with the highest feeding guild richness was Plant Community 7 with granivores, insectivores, frugivores, omnivores and carnivores. The most represented feeding guild was omnivores (Table 5.5). Plant Community 7 with the most feeding guilds also had the highest tree cover. The other three plant communities all had one feeding guild less than Plant Community 7 (Table 5.5). No specific relation was observed in terms of feeding guilds in relation to percentage tree cover and tree height (Figure 5.2).

Table 5.5: A summary of feeding guilds in Planning Area A.

Feeding guilds	Evaluation Nr (Smith, 2004)	Plant comm 4	Plant comm 6	Plant comm 7	Plant comm 8
Granivores	i	-	-	1	-
Insectivores	ii	12	6	12	7
Frugivores	iii	2	1	2	2
Omnivores	iv	19	27	32	13
Carnivores	v	4	4	5	3
Scavengers	vi	-	-	-	-
Herbivores	vii	-	-	-	-
Feeding guild diversity		**4**	**4**	***5**	**4**
Most represented feeding guild		iv	iv	iv	iv

* Highest feeding guild richness in Planning Area A and H

The nesting guild study following of Smith (2004) was discussed in Chapter 3. The investigation focused on the nesting guild richness and the most represented nesting guilds of the birds in the different plant communities of Planning Area A. The most represented nesting guild in Planning Area A was shrub/tree (Table 5.6). The plant community with the highest nesting guild richness (10 guilds) was in Plant Community 7 with the following nesting guilds: tree, structure, tree/structure, reed/grass, ground, shrub, shrub/tree, grass/ground, shrub/grass and parasites. The lowest number of nesting guilds was present in Plant Community 8, which also had a low percentage tree cover.

No specific relation in terms of nesting guild richness in relation to tree height was observed, but in Plant Communities 4 and 7, where the percentage tree cover was higher, the nesting guild richness was also higher. The opposite trend was observed in Plant Communities 6 and 8 (Table 5.6 and Figure. 5.2).

Table 5.6: A summary of nesting guilds in Planning Area A.

Nesting guilds	Evaluation No (Smith, 2004)	Plant Comm 4	Plant Comm 6	Plant Comm 7	Plant Comm 8
Tree nesters	1	11	7	12	8
Structure	2	1	4	3	-
Tree / Structure	3	1	3	4	1
Reed / Grass	4	-	-	1	-
Ground	5	1	1	2	-
Shrub	6	1	1	2	-
Shrub / Tree	7	16	14	19	11
Grass Ground	8	1	1	1	1
Shrub / Grass	9	1	5	4	1
Grass	10	-	-	-	-
Extra limitable	Ex	1	2	2	3
Parasites	P	3	-	2	-
Nesting guild diversity		**9**	**8**	***10**	**5**
Total number of nesting guilds		7	7	7	7

* Highest nesting guild in Planning Area A

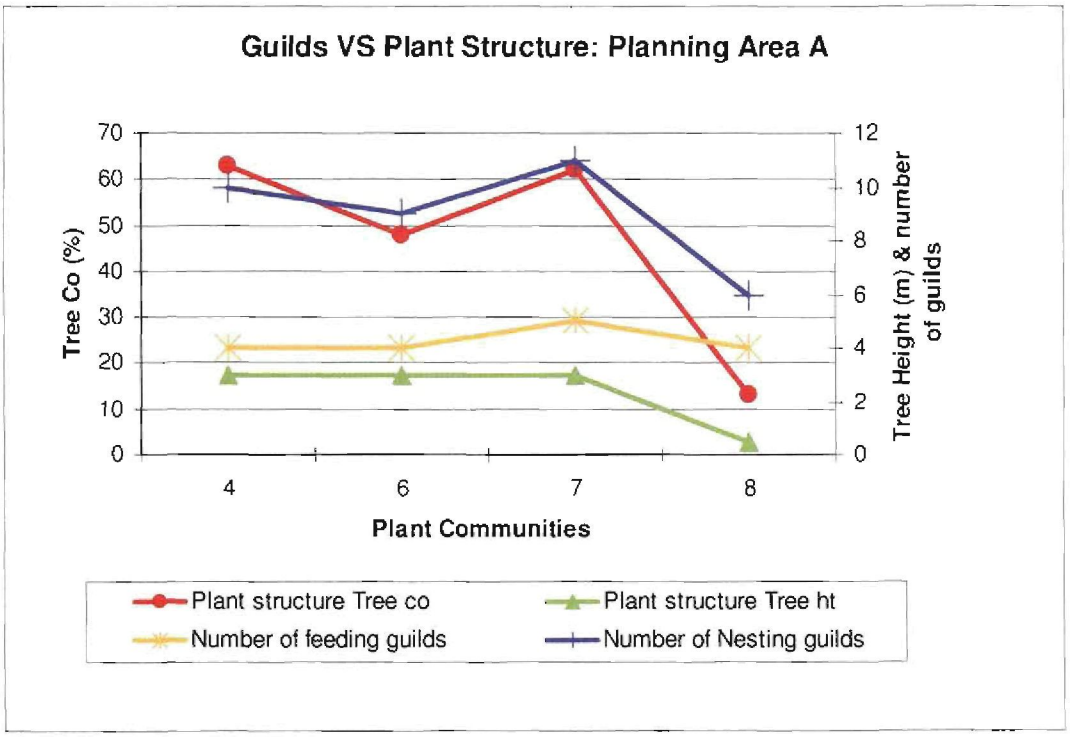


Figure 5.2: The relation between the feeding and nesting guilds and % tree cover (Tree co) and tree height (Tree ht) in the different plant communities of Planning Area A (Plant Communities 4, 6, 7 & 8)

5.2.2.2 Bird numbers, bird species numbers and feeding and nesting guilds associated with tree cover and height in Planning Area H (Nelspruit)

The most recorded bird species in the different plant communities of Planning Area H were the Bar-throated Apalis (10), Streaky-headed Canary (10), Yellow-breasted Apalis (10), Golden weaver (9), Purple-crested Turaco (9), Southern Black Tit (9) and the Orange-breasted Bush-shrike (9). No single species was present in all of the plant communities of Planning Area H (Table 5.7).

Table 5.7: Most represented birds in the different plant communities of Planning Area H.

Common name of birds	Roberts No	Tot number of birds/ Com	Plant Comm 1	Plant Comm 2	Plant Comm 3	Plant Comm 5	Plant Comm 9	Plant Comm 10
Bar-throated Apalis	748	10	2	0	1	1	5	1
Streaky-headed Canary	881	10	1	0	0	2	6	1
Yellow-breasted Apalis	648	10	2	0	1	1	5	1
Golden weaver	816	9	2	1	1	2	0	3
Purple-crested Turaco	371	9	2	1	1	1	4	0
Southern Black Tit	554	9	1	0	1	3	1	3
Orange-breasted Bush-shrike	748	9	2	1	1	2	0	3

The highest numbers of birds and bird species recorded in Planning Area H were in Plant Community 5, with 124 birds and 90 species (Table 5.8 and Figure 5.3). Plant Community 5 was situated on the hills of Nelspruit with dominant tree species such as *Englerophytum magalismontanum* and *Sterculia murex* (Table 5.2). This community had an average tree height of 6m with the highest tree cover of all plant communities with 62% cover, shrub height was 1m with 33% cover, grass height was 90cm with 17% cover and forb height was 29cm with 29% cover (Table 4.4). An average number of 53 plant species was recorded per relevé of which 8% were exotic, 1% was declared invaders and 4% were declared weeds (Table 4.5).

The lowest numbers of birds and bird species recorded in Planning Area H were in plant community 3 with 29 birds and 29 bird species (Table 5.8 and Figure 5.3). Plant Community 3 was situated in disturbed streams of Nelspruit with dominant species such as *Amaranthus hybridus* and *Acacia sieberiana* (Table 5.2). The average tree height in this community was 6m with 30% cover, the shrub height was 1.2m with 15% cover, the grass height was 90cm with 6% cover and the forb height was 38cm with 57% cover, which was the highest forb cover of all the communities described (Table 4.4). An average number of 32 plant species per relevé was recorded of which 26% were exotics, 4% were invaders and 18% were declared weeds. This plant community had the lowest plant species richness, an average of 32 plant species per

relevé and the highest percentage (18%) of declared weeds, probably as a result of direct anthropogenic influences (Table 4.5).

There were no specific relation in terms of total number of birds and total number of bird species in relation to tree height, but in Plant Communities 1 and 5, where the percentage tree cover was higher, the total number of birds and the total number of bird species were also higher. The opposite trend was observed in Plant Communities 2 and 3 (Figure. 5.3).

Table 5.8: Number of birds and bird species observed and plant structure (tree height and cover) in different plant communities of Planning Area H

Plant communities	1	2	3	5	9	10
Total number of birds	98	30	29	124	119	73
Total number of bird species	78	30	29	90	35	30
Tree Height (m)	7	6	6	6	3	5
Tree cover (%)	42	23	30	62	30	13

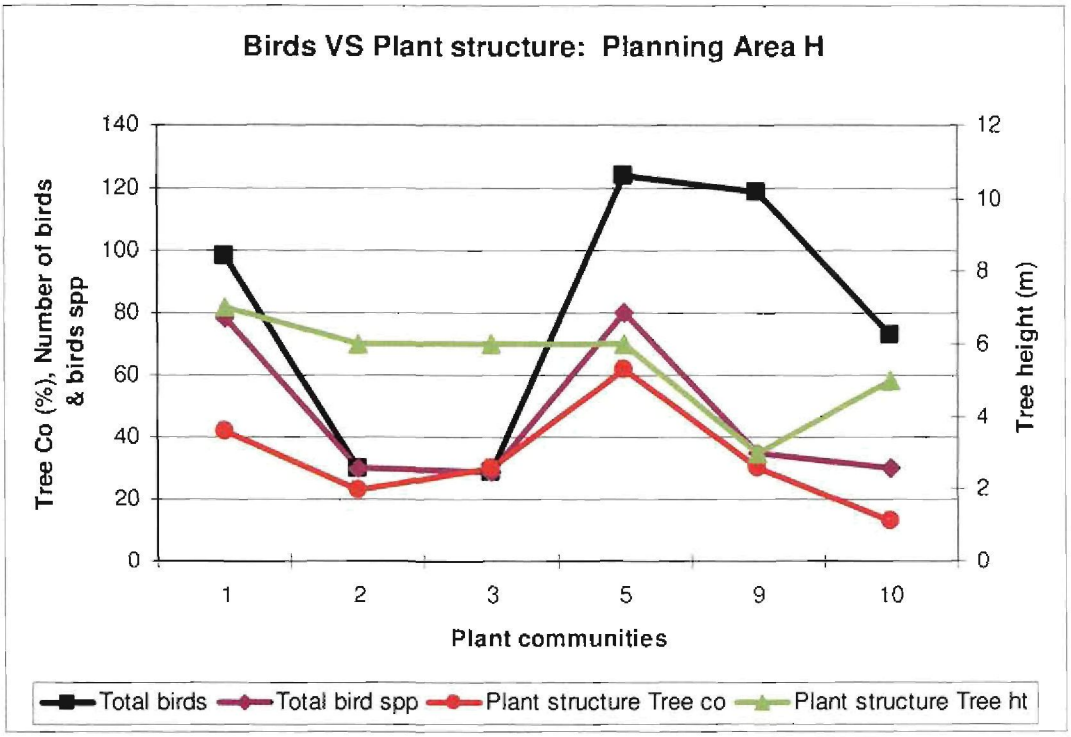


Figure 5.3: The relation between the number of birds (Total No Birds), number of bird species (Total No Bird spp), % Tree cover (Tree co) and Tree height (Tree ht) in the different plant communities of Planning Area H (Plant communities 1, 2, 3, 5, 9 & 10)

The most represented feeding guild in Planning Area H was omnivores (Plant Communities 1, 2, 3, 4 and 9) and insectivores (Plant Community 10) (Table 5.9 and Figure 5.4). The highest

feeding guild richness in Planning Area H was in plant community 5 with granivores, insectivores, frugivores, omnivores and carnivores. Plant community 5 represented the hills and valleys in Nelspruit with dominant tree species such as *Englerophytum magalismontanum* and *Sterculia murex*. It had a high percentage tree cover (62%) and a low percentage grass cover (17%) (Table 4.4). The lowest feeding guild richness was in Plant Community 3, the disturbed streams in Nelspruit. There was no relation between feeding guild richness and tree height as well as percentage tree cover in Planning Area H although plant community 5 with the highest number of feeding guild also has the highest tree cover (Figure. 5.4).

Table 5.9: A summary of feeding guilds in Planning Area H.

Feeding guilds	Evaluation No (Smith, 2004)	Plant Comm 1	Plant Comm 2	Plant Comm 3	Plant Comm 5	Plant Comm 9	Plant Comm 10
Granivores	i	-	-	-	2	-	-
Insectivores	ii	23	10	11	30	13	16*
Frugivores	iii	2	2	1	3	2	1
Omnivores	iv	44	13	14	48	19	11
Carnivores	v	9	5	3	7	1	2
Scavengers	vi	-	-	-	-	-	-
Herbivores	vii	-	-	-	-	-	-
Feeding guild richness		**4**	**4**	**3**	***5**	**4**	**4**
Most represented feeding guilds		iv	iv	iv	iv	iv	ii

* Highest feeding guild richness in Planning Area H

The most represented nesting guilds were the tree and shrub/tree guilds (Table 5.10). The plant communities with the highest nesting guild richness were Plant Communities 1 and 5 with 11 nesting guilds each (Table 5.10). Plant Community 1 represented the rivers and streams (natural) in Nelspruit with trees such as *Syzygium cordatum* and *Breonadia salicina* and Plant Community 5 represented the hills and valleys with dominant tree species such as *Englerophytum magalismontanum* and *Sterculia murex* (Table 5.2). The lowest nesting guild richness was in Plant Communities 2 and 9 with eight nesting guilds each.

No specific relation in terms of nesting guild richness in relation to tree height was observed, but in Plant Communities 1 and 5 where the percentage tree cover was high, the number of nesting guilds was also high. The opposite trend was observed in Plant Communities 2 and 9 (Figure. 5.4).

Table 5.10: A summary of nesting guilds in Planning Area H.

Nesting guilds	Evaluation No (Smith, 2004)	Plant Comm 1	Plant Comm 2	Plant Comm 3	Plant Comm 5	Plant Comm 9	Plant Comm 10
Tree nesters	1	16	10	6	20	10	7
Structure	2	9	1	3	6	2	-
Tree / Structure	3	7	1	3	10	6	1
Reed / Grass	4	2	4	2	4	-	2
Ground	5	3	-	1	2	2	2
Shrub	6	3	-	1	4	3	1
Shrub / Tree	7	22	9	5	22	8	7
Grass Ground	8	3	1	1	3	-	1
Shrub / Grass	9	5	2	3	7	2	5
Grass	10	4	1	2	5	1	3
Extra limitable	Ex	1	1	2	2	1	1
Parasites	P	3	-	-	5	-	-
Nesting guild richness		*11	8	10	*11	8	10
Most represented nest guild		7	1	1	7	1	1&7

* Highest nesting guild in Planning Area H

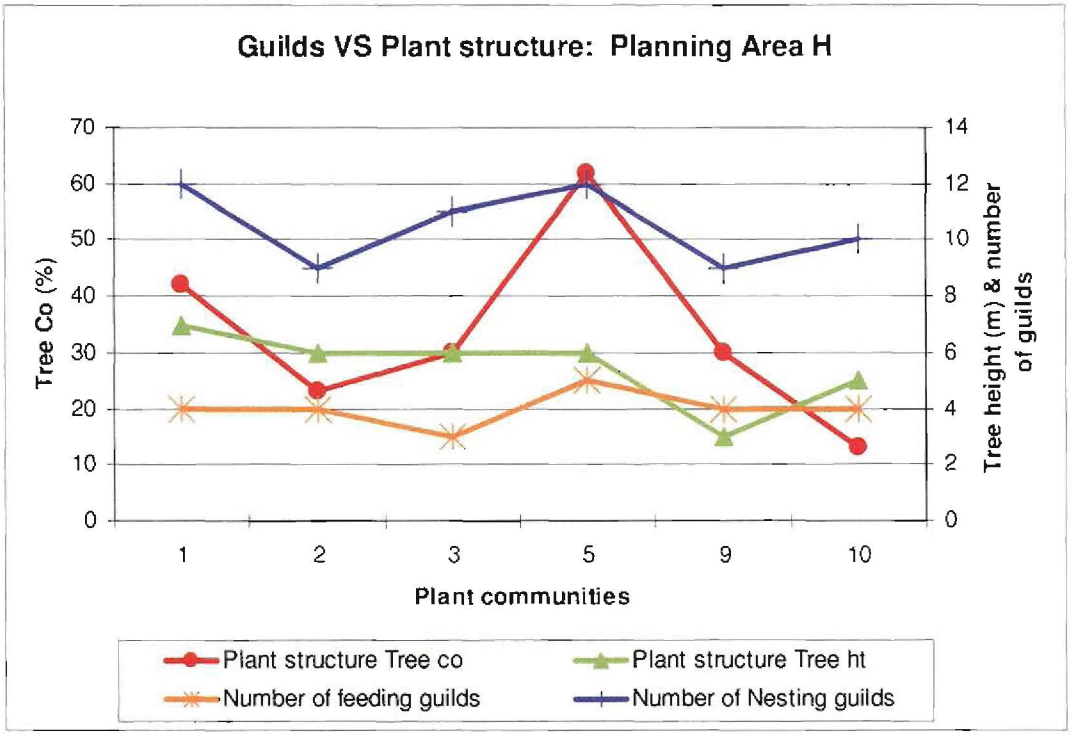


Figure 5.4: The relation between the feeding and nesting guilds and % Tree cover (Tree co) and Tree height (Tree ht) in the different plant communities of Planning Area H (Plant Communities 1, 2, 3, 5, 9 & 10)

5.2.2.3 Total bird numbers, number of bird species, feeding and nesting guilds associated with plant structure (tree height and cover) in the different biotopes

The classification of the four biotopes in natural open spaces of Mbombela is discussed in Chapter 4. A brief summary of the plant communities, type of open spaces and dominant plant structure type, as described in Chapter 4, is given in Table 5.11. A summary of the tree structure (tree height and cover) in the four biotopes is given in Table 5.12, as discussed in Chapter 4, Table 4.4.

Table 5.11: A summary of the biotopes in the natural open spaces of Mbombela

Biotope	Plant description	Dominant plant structure type
1. Rivers and streams	*Phragmites australis – Ageratum houstonianum* Riparia woodland	Tree/Forb
2. Hills and valleys	*Pavetta shumanniana – Gymnosporia heterophylla* Woodlands	Stunted trees
3. Granite outcrops	*Cyperus rupestris – Cyanotis speciosa* Herbaceous open woodlands on exposed granite outcrops.	Shrubs/grass
4. Grasslands	*Lannea edulis – Heteropogon hirta* Grasslands	Grass

Table 5.12: A summary of the plant structure (tree height and cover) of different biotopes in the natural open spaces in Mbombela.

	Rivers and streams	Hills and valleys	Granite outcrops	Grassland
Avg Tree Height (m)	5.5	4	1.75	5
Avg Tree Cover (%)	39.5	57.3	21.5	13

The bird species recorded most in the different biotopes are indicated in Table 5.13. The most dominant bird species in Biotope 1 (Rivers and streams) were the Purple-crested Turaco (5), Black-eyedped Bulbul (5), Heuglin's Robin (5) and Orange-breasted Bush-shrike (5). In Biotope 2 (Hills and valleys) the bird species recorded most were the European swallow (12), Black-eyedped Bulbul (15), Neddicky (7) and Yellowed-eyed Canary (10). Birds recorded most in Biotope 3 (Granite outcrops) were the Golden-tailed Woodpecker (6), Cardinal Woodpecker (7) and Streaky-headed Canary (6). In Biotope 4 (Grasslands), the Neddicky (3), Fiscal Shrike (3), Puffback (3) and Black-crowned Tchagra (3) were recorded most. The highest occurrence of bird species in Mbombela was of the Black-eyedped Bulbul (23) followed by the European Swallow (16), Purple-crested Turaco (16) and the Orange-breasted Bush-shrike (15). The birds which occurred in all biotopes were the Bar-throated Apalis, Yellow-breasted Apalis, Neddicky, Fiscal Shrike, Puffback, Black-crowned Tchagra and Orange-breasted Bush-shrike.

Table 5.13: Most represented bird species in the different biotopes of natural open spaces of Mbombela.

Common name	Roberts bird No	Total bird spp	Biotope 1 Rivers & streams	Biotope 2 Hills and valleys	Biotope 3 Granite outcrops	Biotope 4 Grasslands
Emerald-spotted Dove	358	9	1	6	2	
Purple-crested Turaco	371	16	5	6	5	
Golden-tailed Woodpecker	483	10	2	2	6	
Cardinal Woodpecker	486	10	2	1	7	
European Swallow	518	16	2	12	2	
Fork-tailed Drongo	541	9	1	3	5	
Black-eyed Bulbul	568	23	5	15	3	
Heuglin's Robin	599	10	5	5		
Bar-throated Apalis	645	11	4	1	5	1
Yellow-breasted Apalis	648	12	3	3	5	1
Neddicky	681	13	1	7	2	3
Black Flycatcher	694	8	3		5	
Fiscal Shrike	732	13	3	6	1	3
Puffback	740	14	4	6	1	3
Black-crowned Tchagra	744	13	2	6	2	3
Orange-breasted Bush-shrike	748	15	5	6	1	3
Yellow-eyed Canary	869	14	4	10		
Bully Canary	877	7	1		5	1
Streaky-headed Canary	881	10	1	2	6	1

The most birds recorded (290) were in Biotope 2 (Hills and valleys) with the highest bird species richness (119) in Biotope 1 (Rivers and streams) (Table 5.14). The average tree height in Biotope 1 (Rivers and streams) was 5.5m with 39.5% tree cover and in Biotope 2 (Hills and valleys) the average tree height was 4m with 57.3% tree cover (Table 5.11, Table 5.12 and Figure 5.5).The lowest number of birds (73) with the lowest number of bird species (30) recorded was in Biotope 4 (Grassland) (Table 5.13 and Figure 5.5). Biotope 4 (Grassland) was situated in Nelspruit and had an average tree height of 5m with 13% cover (Table 5.11, 5.12 and Figure 5.5).

No specific relation in terms of the total number and birds or total number of species in relation to tree height was observed, but in Biotopes 1 and 2, where the total number of birds and total number of species were higher, the percentage tree cover was also higher. The opposite trend was observed in Biotopes 3 and 4 (Figure 5.5).

Table 5.14: Total number of birds and number of bird species in different biotopes of the natural open spaces of Mbombela.

	Rivers and streams	Hills and valleys	Granite outcrops	Grassland
Total number of birds	202	290	150	73
Total number of bird species	119	107	53	30

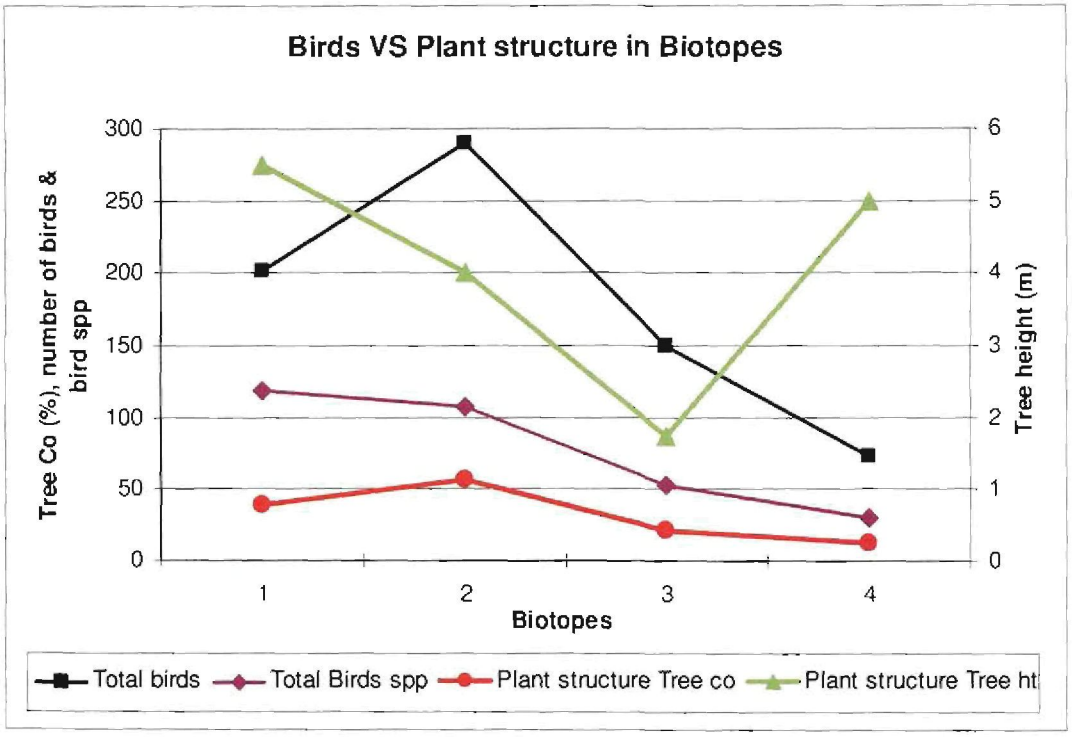


Figure 5.5: The relation between the number of birds (Total No Birds), number of bird species (No Bird spp), % Tree cover (Tree co) and Tree height (Tree ht) in the different biotopes.

The highest feeding guild richness was in Biotope 2 with granivores, insectivores, frugivores, omnivores and carnivores. The rest of the biotopes had four feeding guilds each. The most represented feeding guild in Mbombela was omnivores (Biotopes 1, 2 and 3), followed by insectivores in Biotope 4 (Table 5.15 and Figure 5.6). No specific relation in terms of feeding guild richness in relation to tree height and percentage tree cover was observed (Figure 5.6).

Table 5.15: A summary of feeding guilds in the different biotopes of the natural open spaces of Mbombela.

Feeding guilds	Biotope 1 Rivers and streams	Biotope 2 Hills and valleys	Biotope 3 Granite outcrops	Biotope 4 Grassland
Granivores	-	2	-	-
Insectivores	37	30	16	**16**
Frugivores	4	3	3	1
Omnivores	**59**	**60**	**30**	11
Carnivores	19	12	4	2
Scavengers	-			-
Herbivores	-			-
Feeding guild richness	**4**	**5**	**4**	**4**
Most represented feeding guild	Omnivores	Omnivores	Omnivores	Insectivores

The highest nesting guild richness was in Biotopes 1 and 2 with 12 nesting guilds each. The most represented nesting guilds were tree and shrub/tree (Table 5.16). No relation in terms of nesting guild richness in relation to tree height and percentage tree cover was observed (Figure 5.6).

Table 5.16: A summary of nesting guilds in biotopes of the natural open spaces of Mbombela.

Nesting guilds	Biotope 1 Rivers and streams	Biotope 2 Hills and valleys	Biotope 3 Granite outcrops	Biotope 4 Grassland
Tree	**29**	**25**	14	**7**
Structure	11	10	2	
Tree / Structure	9	11	6	1
Reed / Grass	4	4		2
Ground	4	4	2	2
Shrub	3	4	3	1
Shrub / Tree	**29**	**24**	**18**	**7**
Grass Ground	4	3	1	1
Shrub / Grass	8	8	2	5
Grass	6	5	1	3
Extra limitable	6	4	4	1
Parasites	6	5		
Nesting guild richness	**12**	**12**	**10**	**10**
Most representative nesting guild	Shrub/Tree	Shrub/Tree	Shrub/Tree	Shrub/Tree

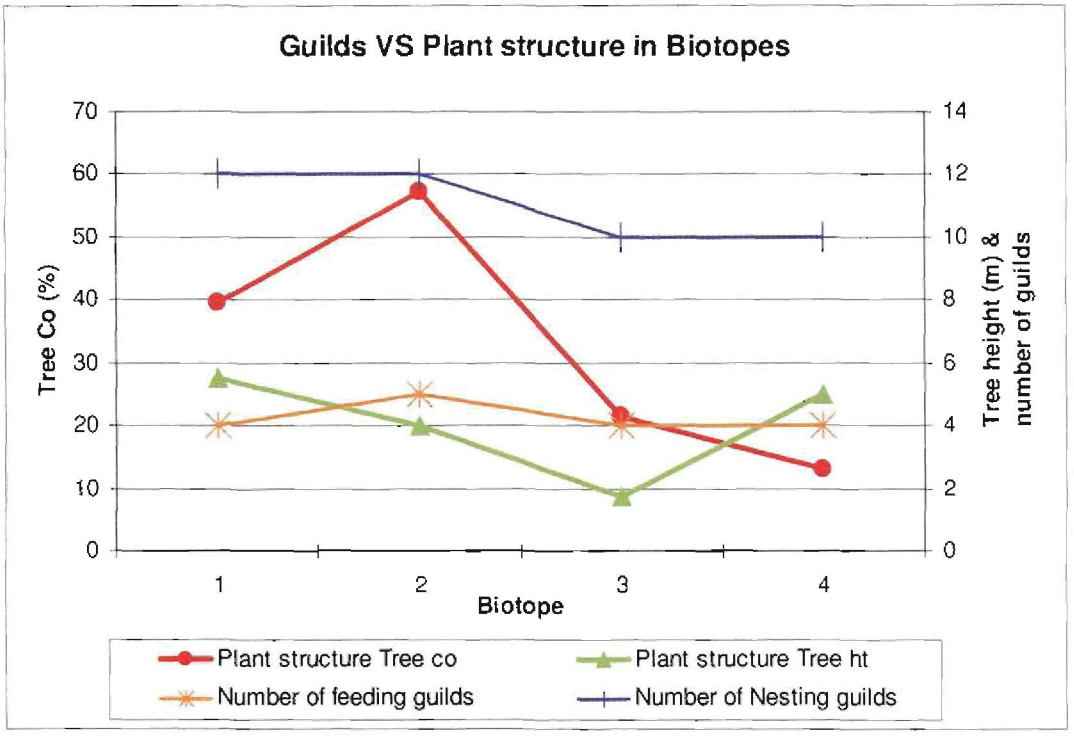


Figure 5.6: The relation between the feeding and nesting guilds and % Tree cover (Tree co) and Tree height (Tree ht) in the different biotopes of the natural open spaces of Mbombela.

5.2.3 Summary of bird study

The first aim of the bird study was to compare the different plant communities in the two Planning Areas with respect to the total number of birds and total number of bird species. The highest number of birds and highest number of bird species were observed in Plant Community 7 of Planning Area A and Plant Community 5 of Planning Area H (Table 5.4, 5.8). The biotope with the highest number of birds was Biotope 2 (Hills and valleys), while Biotope 1 (Rivers and Streams) had the highest number of bird species. The lowest number of birds and bird species was observed in Plant Community 8 of Planning Area A, Plant Community 3 of Planning Area H and Biotope 4 (Grasslands) (Table 5.14).

The next aim was to compare the different plant communities in the two planning areas with respect to feeding and nesting guild diversity. The highest feeding and nesting guild diversity of Planning Area A was observed in Plant Community 7 (Table 5.5 and 5.6), while in Planning Area H Plant Community 5 had the highest feeding guild diversity and Plant Community 1 and 11 had the highest nesting guild diversity. The biotope with the highest feeding guild diversity was Biotope 2 (Hills and valleys), and Biotope 1 (Rivers and streams) and Biotope 2 (Hills and valleys) had the highest nesting guild diversity (Table 5.15 and 5.16).

The third aim was to compare the different plant communities and biotopes with respect to the relation of total number of birds, total number of bird species in relation to percentage tree cover and tree height. A relation was observed in terms of the total number of birds and total number of bird species in relation to percentage tree cover in Planning Area H and in the different biotopes. A relation in terms of nesting guild diversity and percentage tree cover was observed in Planning A, H and the biotopes. There was a relation between nesting guilds and tree height in Planning Area H and in the different biotopes (Table 5.17).

Table 5.17: A summary of the relation between tree heights (m) / tree cover (%) and total number of bird / feeding / nesting guilds in Mbombela study area, where + indicates a relation, and – indicates no relation.

Number of bird, number of bird species, nesting and feeding guild vs. tree structure	Planning Area A	Planning Area H	Biotopes
Total number of birds vs. % Tree cover	-	+	+
Nesting guild vs. % Tree Cover	+	+	+
Feeding guild vs. % Tree Cover	-	-	-
Total number of birds vs. % Tree Height	-	-	-
Nesting guild vs. % Tree Height	-	+	+
Feeding guild vs. % Tree Height	-	-	-

No statistical analysis was done because it was not the aim of the study. The results, however, are an indication that trees are important sites for breeding in urban areas, as the highest numbers of birds and bird species were recorded in areas with a high percentage tree cover and most of the birds preferred trees/shrubs as nesting sites as was also observed by Jokimäki (1999) and Sandström *et al.* (2006).

According to this study, the most vulnerable plant communities in terms of total number of birds and bird species were Plant Community 7 in Planning Area A and Plant Communities 1 and 5 in Planning Area H. The most important biotopes for conservation of birds were Biotope 1 (Rivers and streams) and Biotope 2 (Hills and valleys).

5.3 Carbon Storage of trees in Natural open spaces of Mbombela.

5.3.1 Introduction

An increased level of carbon dioxide and global warming is a worldwide concern (Jo & McPherson, 1995) and atmospheric carbon is estimated to increase annually (Nowak & Crane, 2002). Cities are net producers of carbon dioxide with lower amounts of stored carbon (Whitford *et al.*, 2001) and this concern has evoked interest in the potential for urban green

spaces to help reduce levels of atmospheric carbon (Jo & McPherson, 1995). Trees can combat increasing levels of atmospheric carbon through their growth process (Nowak, 1993; Akbari, 2002; Johnson & Gerhold, 2003), reduce air pollutants by absorbing gaseous pollutants through their stomata and also reduce temperatures through direct shading (Nowak *et al.*, 2006; Yang *et al.*, 2005). According to Myeong *et al.* (2006), urban trees are important in the reduction of atmospheric CO_2 through assimilation. Tall trees that have a high percentage tree cover (biomass) can possibly store more carbon than short trees with a low percentage tree cover (Nowak, 1991; Peper *et al.*, 2001; Akbari, 2002).

The current study used vegetation descriptions, especially tree height and percentage tree cover, as discussed in Chapter 4, to compare the carbon storage value of trees in urban natural open spaces of Mbombela. Scores as discussed in Chapter 3 were given to trees according to the tree height and percentage tree cover for the evaluation of carbon storage value. These scoring values are used in Chapter 7 for the evaluation of biotopes worthy of protection and in Chapter 8 for planning and management recommendations to the Mbombela Municipality.

The aim of this study was to calculate the possible carbon storage value of trees in the different plant communities of Planning Areas A and H as well as in the four different biotopes.

5.3.2 Results and discussion

The trees in Planning Area A were stunted and destructed, while the trees in Planning Area H were fully grown and not as dense as those in Planning Area A. Trees in Planning Area A were not as tall as the trees in Planning Area H. Trees in Planning Area A (Plant Communities 4, 6, 7 and 8) had an average height of 2.4m, while trees in Planning Area H (Plant Communities 1, 2, 3, 5, 9 and 10) had an average height of 5.5m. The average percentage tree cover in Planning Area A was higher (46.4%) than in Planning Area H (33.3%), see Table 5.18 and Figure 5.7.

Table 5.18: A summary of the average tree height and average percentage tree cover in the different plant communities of Planning Areas A and H.

	Avg tree Height (m)	Avg Tree Cover (%)
Planning Area A		
Plant community 4	3	63
Plant community 6	3	48
Plant community 7	3	62
Plant community 8	0.5	13
Avg of Planning Area A	**2.4**	**46.5**
Planning Area H		
Plant community 1	7	42
Plant community 2	6	23
Plant community 3	6	30
Plant community 5	6	62
Plant community 9	3	30
Plant community 10	5	13
Avg of Planning Area H	**5.5**	**33.3**

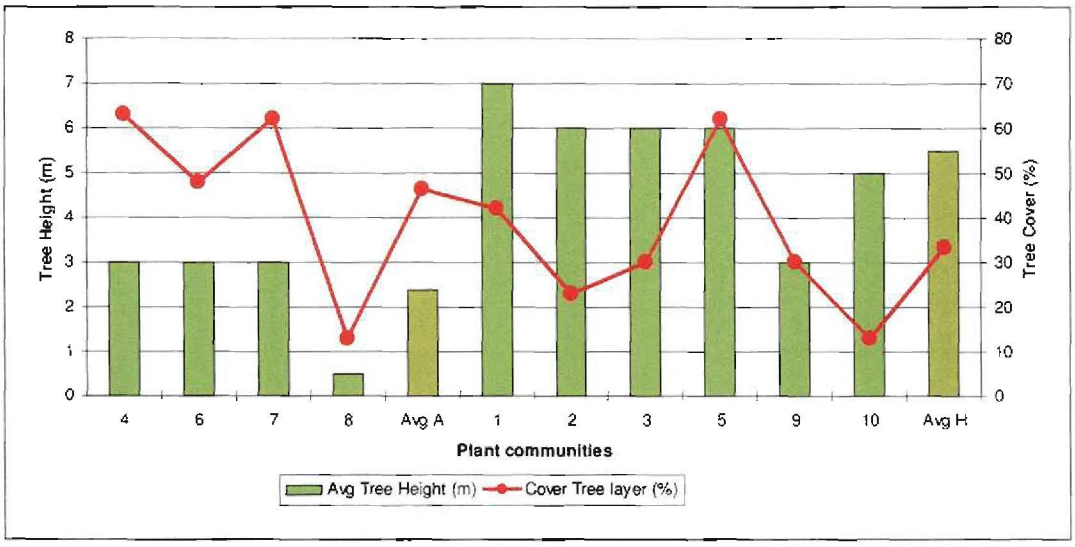


Figure 5.7: The tree height, average tree height, percentage tree cover and average percentage tree cover in the different plant communities of Planning Areas A (Hazyview) and H (Nelspruit).

Biotopes 1 and 4 had a tree height of 5.5m and 5m, with 39.5% and 13% tree cover, respectively. In Biotope 2, the trees had a height of 4m and 57% cover while Biotope 3 had a tree height of 1.75m with 21.5% tree cover (Table 5.12).

To evaluate the different plant communities and biotopes for a carbon storage value, scores were given according to the method discussed in Chapter 3. The plant communities with the highest scores were Plant Community 4 with a score of 6 in Planning Area A and in Planning Area H, and Plant Communities 1 and 5 with a score of 7. Biotope 2 (Hills and valleys) was the biotope with the highest score with a score of 8 (Table 5.19). These plant communities and this biotope had the tallest trees with a high percentage tree cover (Table 5.18).

Plant communities and biotope with low scores were Plant Community 8 (3) in Planning Area A and Plant Communities 2, 9 and 10 with a score of 4 each in Planning Area H while Biotope 3 (Granite outcrops) had a score of 2 (Table 5.19). These plant communities and this biotope had the shortest trees with low percentage tree cover (Table 5.18). Better management practices and planning have to be implemented to ensure healthy urban open spaces with tall trees and a higher percentage tree cover.

Table 5.19: Score for tree height, % tree cover and total scores for the different plant communities in Planning Areas A and H as well as for the different Biotopes.

Plant community / Biotope		Tree height score	Tree cover score	Total score for Tree height and Cover
Planning Area A	4	2	4	**6**
	6	2	3	5
	7	2	3	5
	8	1	2	3
Planning Area H	1	4	3	**7**
	2	3	1	4
	3	3	2	5
	5	3	4	**7**
	9	2	2	4
	10	3	1	4
Biotope	1	3	2	5
	2	4	4	**8**
	3	1	1	2
	4	3	1	4

5.4 Conclusion

The results of this current study indicated that trees are important sites for breeding in urban areas, as the highest numbers of birds and bird species were recorded in areas with a high percentage tree cover and most of the birds preferred trees/shrubs as nesting sites. Large trees and a multi-layered vegetation structure are important components in maintaining high bird

species diversity in urban green spaces (Sandström *et al.*, 2006). According to the bird study the most important plant communities are Plant Community 7 in Planning Area A and Plant Communities 1 and 5 in Planning Area H. The most important Biotopes for the conservation of birds are Biotope 1 (River and streams) and Biotope 2 (Hills and valleys).

By using a scoring system for tree height and percentage tree cover, a possible indication of which plant communities and biotopes could have the best value for stored carbon was obtained. The plant communities and biotope with the highest scores were Plant Community 4 in Planning Area A, Plant Communities 1 and 5 in Planning Area H and Biotope 2 (Hills and valleys) in both Planning Areas. These plant communities and biotope had the tallest trees and highest percentage tree cover. Planning and managing of urban green areas with large trees are part of the solution in decreasing the level of carbon in urban areas and providing habitats to increase numbers of birds and other species.

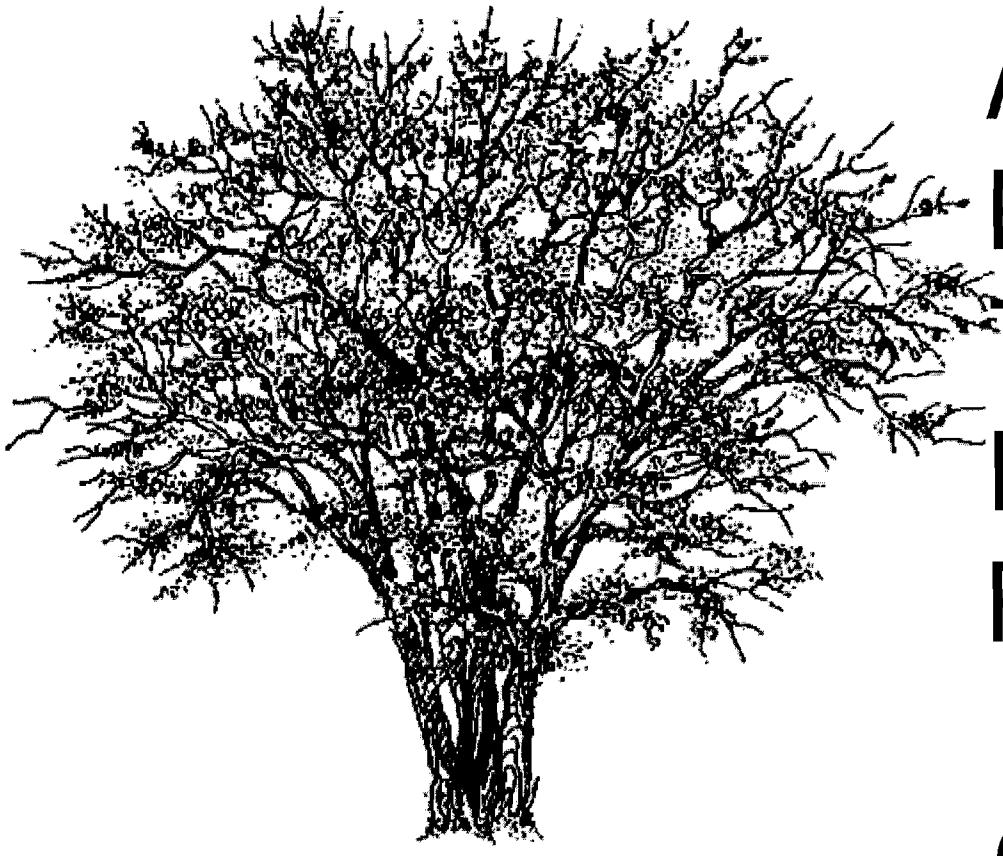
The most important plant community in Planning Area A was Plant Community 7, because it had the highest number of birds and number of bird species and the most feeding and nesting guilds (Table 5.20). Plant Community 4 had a higher carbon storage score than Plant Community 6 because of the higher percentage tree cover (Table 5.20). In Planning Area H, Plant Communities 1 and 5 were the most important plant communities, where Plant Community 1 had a high carbon storage score (7) and the highest number of nesting guilds (11) (Table 5.20). Plant Community 5 and Biotope 2 had the highest score and numbers in all five criteria of evaluation (Table 5.20).

Table 5.20: Summary of the carbon storage scores, total number of birds, total bird species richness, total number of nesting and feeding guilds in Mbombela.

Plant community or Biotope		Carbon storage scores	Number of birds	Number of bird species	Total number of feeding guilds	Total number of nesting guilds
Planning Area A	4	**6**	48	37	4	9
	6	5	56	38	4	8
	7	5	**110**	**52**	**5**	**10**
	8	3	31	25	4	5
Planning Area H	1	**7**	98	78	4	**11**
	2	4	30	30	4	8
	3	5	29	29	3	10
	5	**7**	**124**	**90**	**5**	**11**
	9	4	119	35	4	8
	10	4	73	30	4	9
Biotope	1	5	202	119	4	**12**
	2	**11**	**290**	**107**	**5**	**12**
	3	2	150	53	4	10
	4	4	73	30	4	10

Nowak *et al.* (2000) stated that vegetation in cities, particularly trees can directly and indirectly affect urban air quality and therefore it is important to manage the open space, especially in Plant Communities 5 and 7 and Biotope 2. It is also important to improve the other plant communities and biotopes to be on the same level and conditions as Plant Communities 5 and 7 and Biotope 2. This information is used for the evaluation of biotopes (Chapter 6) and for the recommendations to the municipality on management and improvement of open spaces in Mbombela Municipality (Chapter 8).

CHAPTER 6



Biotope mapping and Evaluation of biotopes worthy of protection

CHAPTER 6
BIOTOPE MAPPING AND EVALUATION OF BIOTOPES WORTHY OF PROTECTION

6.1 Introduction

Natural open spaces can be important natural habitats and are ecologically significant for biodiversity in the urban context. Therefore, natural open spaces are vulnerable to the effects of development and urban planners are constantly under pressure to conserve and enhance the natural environment (Freeman, 1999). Decision makers should also strive to understand the environment (Breuste, 2004), and minimize the impact on the environment as well as the use of limited natural resources in order to improve the conservation of indigenous vegetation in urban areas (Florgård, 2000). To demonstrate the importance of natural open spaces, Cornelis and Hermy (2004) used a scoring system for the evaluation of open spaces to compare these areas for future planning. Freeman (1999) assigned quantitative values based on ecological, amenity and development criteria to be used by planners to compare the relative ecological and amenity merits of sites facing development so that efforts can be focused on conserving those sites where the ecology is deemed most valuable or threatened.

The aim of this chapter was to indicate the different biotopes on the existing maps, to evaluate natural open areas of studied areas in Mbombela (Planning areas A and H) and to use these evaluation scores to illustrate the importance of natural open spaces spatially on a map. Previously available data (bird data from Nelspruit) and data collected as discussed in the previous chapters were used for the evaluation. Recommendations for future planning and management in chapter 8 is based on the evaluation of biotopes in this chapter.

6.2 Biotope mapping

Four biotopes were classified based on the phytosociological data (Chapter 4), further described using bird, and carbon storage data (Chapter 5). The four biotopes were:

1 Rivers and streams.
2 Hills and valleys
3 Granite outcrops
4 Grasslands

The four biotopes are indicated on maps with Planning Area A in Figure 6.1 and Planning Area H in Figure 6.2.

6.3 Evaluation of the four biotopes

Mbombela Local Municipality did an Importance Rating (IR) in the Draft Environmental Management Framework (EMF) (2006) by using the integration of baseline information layers and also including current policies (see Chapter 7). The baseline information was transformed into secondary information through a series of sensitivity analyses whereby the importance of environmental features was rated by a specialist in the relevant field (ecologist, geomorphologist, etc). Certain areas were classified into three categories of sensitivity i.e. high, medium or low. Residential areas were rated as areas with a low sensitivity and natural open spaces in urban areas were overseen, because rivers and streams were too narrow to detect (Figure 7.3 and 7.4).

The current study was more specific and included smaller areas like rivers and natural open spaces in a residential area with accompanied rating scale. Using the vegetation classification of Mbombela's natural open spaces, four biotopes were identified namely Rivers and streams, Hills and valleys, Granite outcrops and Grasslands as discussed in Chapter 4. The rating of the biotopes was based on three criteria namely vegetation, bird surveys and habitat, as discussed in Chapter 3 (Table 3.5).

Areas with the presence of Red Data Species had a high ecological value depending on the importance of the red data species. Four plant species and one bird species listed in the Red Data List were found during the survey (Table 6.1).

Table 6.1: List of Red Data plant (Hilton-Taylor, 1996) and bird species (Barnes, 2000) found in sampling areas of Mbombela.

Listed in Red Data List	
Combretum collinum	K – Insufficiently known
Bridelia cathartica	nt – not threatened anymore
Gladiolus hollandi	nt – not threatened anymore
Catha edulis	nt – not threatened anymore
Falco peregrinus (R171 - Peregrine falcon)	VU - Vulnerable

6.3.1 Biotope 1: Rivers and streams

Biotope 1 included four plant communities of which one relevé was on the banks of the Sand River and streams in Hazyview and the others were on the banks of the Crocodile River and a stream in the Nelspruit Nature Reserve (Figure 6.1 and 6.2). The Sand River (Plant Community 4) is a natural open area in Nkambeni (Planning Area A) with large trees and had the lowest presentation declared weed and invader species in biotope 1. In Planning Area A, the residential area is classified as a rural residential area with subsistence farming and vegetation in and around Planning Area A is used for daily livelihood. Biotope 1 falls in the following Planning Precincts: H3, H7, H8, H12 and H15 (Figures 3.3 and 3.5). Planning area A had no

control of agricultural activities and the removal of plant species while the Crocodile River in Planning Area H was protected within the Botanical garden and the Greenbelt area. It was situated adjacent to industrial and agricultural activities on the perimeter of the residential areas and residential activities had an affect on the riparian vegetation.

Table 6.2 shows that Biotope 1 had an average of 38 different plant species per plant community and had an average rating of 2.25. An average of 79% of this plant species was indigenous with a rating of 3.50. Red data plant species found in this biotope included *Combretum collinum, Bridelia cathartica* and *Gladiolus hollandi.* These species are not threatened anymore, but are included in the Red data List (Hilton-Taylor, 1996) and were therefore still used for the evaluation, giving the biotope a rating of 0.5. Declared weeds were rated as 1.75, with 19.4% declared species found in this biotope (the highest rating in the four biotopes for declared plants). Tall trees with a high percentage tree cover are important nesting sites and food sources for birds as well as important indicators for carbon storage. Biotope 1 had many tall trees with a high percentage tree cover and carbon storage was rated 3. The total average score for vegetation in Biotope 1 was 11.00.

An average of 44 birds was recorded in Biotope 1 with a rating of 2.5. No RDL species were recorded and this was not rated. The feeding guild had an average rating of 2.75 while the nesting guild had a rating of 3.50. The total average score for birds in Biotope 1 was 8.75 (Table 6.2).

Many of the rivers and streams were connected with each other and networking was rated as moderate with a value of 3. Human impact had a high influence on the species composition and the presence of declared species in riparian zones with Nelspruit. The human impact was notably high and it was rated as 2.25, the highest rating for the four biotopes. The threats from adjacent land uses had a high impact on the environment and were rated as 1.75. The evaluation of socio-economic use was low with a rating of 2.50. The total score for habitat evaluation in Biotope 1 was 9.50 (Table 6.2).

For the total score, the score of the three criteria, vegetation, birds and habitat were added to evaluate the protection value of the biotope, according to the methods discussed in Chapter 3. The final rating of Biotope 1 was 29.25 (Table 6.2), which is rated as medium ecological value. The presence of declared weed and human impacts had a tremendous influence on the ecological status of this biotope and it is suggested that these areas have to be rehabilitated by removing declared species and to reduce human impacts. It is important to have a management plan to improve the status and to monitor these areas yearly as discussed in chapter 9.

Table 6.2: Evaluation of Biotope 1: Rivers and streams in Mbombela

	Criteria	Biotope 1: Rivers and streams									
	Plant community	1		2		3		4		Average	
		Data value	Rating Value	Data Value	Rating Value	Data Value	Rating Value	Data Value	Rating Value	Data Value	Rating Value
Vegetation	Spp richness (Avg)	34	2	36	2	32	2	51	3	38	2.25
	Indigenous spp (%)	80	4	69	3	74	3	91	4	79	3.50
	RDL (Total)		0		0	1	1	4	1	1	0.50
	Declared weeds (%)	17.6	2	30.5	1	21.8	1	7.8	4	19.4	1.75
	CO_2 storage (Value)	7	4	4	2	5	3	6	3	6	3.00
	Total vegetation score										**11.00**
	Avg rating										**2.20**
Birds	Total birds (Avg)	78	4	30	2	29	2	37	2	44	2.50
	RDL (Total)										0
	Feeding guild (Avg)	4	3	4	3	3	2	4	3	4	2.75
	Nesting guild (Avg)	11	4	8	3	10	4	9	3	10	3.50
	Total birds score										**8.75**
	Avg rating										**2.19**
Habitat	Networking (Value)	3	3	4	4	3	3	2	2	3	3.00
	Human impacts (Value)	9	3	26	1	17	2	13	3	16	2.25
	Adjacent land use (Value)	3	3	1	1	1	1	2	2	2	1.75
	Socio-economics (Value)	14	2	17	3	13	2	21	3	16	2.50
	Total habitat score										**9.50**
	Avg rating										**2.38**
	Final score										**29.25**

6.3.2 Biotope 2: Hills and valleys

Bbiotope 2 consisted of Plant Communities 5, 6 and 7, which were woody natural open spaces with tall trees on slopes, hills and ridges (Figure 6.2 and 6.3). Plant Community 5 (Planning Area H) had tall trees and Plant Communities 6 and 7 (Planning Area A) had short, stunted trees. Biotope 2 falls within the following Planning Precincts: A2, H8, H12 and H15 (Figures 3.3 and 3.5).

Biotope 2 had an average of 55 plant species per plant community with a rating of 3.33 and most of the plants were indigenous plants (94%) with a rating of 4. As previously mentioned, the red data species, *Gladiolus hollandi, Catha edulis, Combretum collinum* and *Bridelia cathartica* are listed as not sufficiently known (K) or not threatened (nt), but were included in the Red Data List (Hilton-Taylor, 1996). This species were found in this biotope and was therefore rated as 1 with low importance. The presence of these listed species in all three plant communities of Biotope 2 made these areas more vulnerable and sensitive for change of land use and for development, although the average rating was 1. Declared invaders were present in all the plant communities but with a relatively low presence and were rated as 4. Although trees in Planning Area A were stunted in Biotope 2, the percentage tree cover was higher and an important indicator for carbon storage. The average rating for carbon storage in Biotope 2 was 3.33. The total average score for vegetation in Biotope 2 was 15.67 with an average score of 3.13, the highest contribution for the ecological value in biotope 2 (Table 6.3).

The average number of birds in this biotope was 60 with a rating of 3 and a rating of 0.33 for red data species (Peregrine Falcon) found in Plant Community 5. With the woody species in Biotope 2, the feeding and nesting guilds had ratings of 3 and 3.67, respectively. The total average score for birds in Biotope 2 was 10.00 and an average score of 2.50 (Table 6.3).

The networking of Biotope 2 was low to moderate with an average rating of 2.67. The human impacts were low with a rating of 3.33. Threats from the adjacent land uses were high with a rating of 2.33 and could possibly have an affect on the natural environment. The socio-economic rating of 3.33 was high and had the potential to be used for tourist and recreational uses. The total average score for habitat criteria was 11.67, with an average score of 2.95 (Table 6.3).

The final total score for Biotope 2 was 37.33 (Table 6.3) and is according to the evaluation criteria as discussed in Chapter 3 of high ecological value. This biotope is sensitive with the RDL species that were present in every plant community. According to the evaluation this biotope are proposed to be protected and have to be managed to lift the ecological value of this sensitive biotope, according to management plans as discussed in Chapter 8.

Table 6.3: Evaluation of Biotope 2: Hills and valleys

Section	Criteria	Biotope 2: Hills and valleys							
	Plant community	5		6		7		Average	
		Data value	Rating value	Data value	Rating value	Data value	Rating value	Data value	Rating Value
Vegetation	Spp richness (Avg)	53	3	52	3	60	4	55	3.33
	Indigenous spp (%)	92	4	94	4	97	4	94	4.00
	RDL (Total)	3	1	3	1	6	1	4	1.00
	Declared weeds (%)	3.7	4	1.9	4	3.3	4	3.0	4.00
	CO_2 storage (Value)	7	4	5	3	5	3	6	3.33
	Total vegetation score								**15.67**
	Avg rating								**3.13**
Birds	Spp Richness (Avg)	90	4	38	2	52	3	60	3.00
	Red data (Total)	1	1	0	0	0	0	0	0.33
	Feeding guild (Avg)	5	3	4	3	5	3	5	3.00
	Nesting guild (Avg)	11	4	8	3	10	4	10	3.67
	Total birds score								**10.00**
	Avg rating								**2.50**
Habitat	Networking (Value)	3	3	3	3	2	2	3	2.67
	Human impacts (Value)	6	4	11	3	11	3	9	3.33
	Adjacent land use (Value)	3	3	2	2	2	2	2	2.33
	Socio-economics (Value)	24	4	19	3	20	3	21	3.33
	Total habitat score								**11.67**
	Avg rating								**2.95**
	Final score								**37.33**

6.3.3 Biotope 3: Granite outcrops

Biotope 3 was in natural open spaces on soil pockets in granite outcrops in Planning Areas A and H, with relatively small sampling areas. It had a low percentage of tree cover, especially in Plant Community 8 (Figure 6.1 and 6.2). The plot sizes differed depending on the size of the soil pocket on the hills or exposed granite outcrops. Biotope 3 falls within the following Planning Precincts: A2, H14 and H15 (Figure 3.3 and 3.5).

Biotope 3 had an average of 39 plant species per plant community and a rating of 2.5, with 96% indigenous plant species with a rating of 4. The Red data species recorded in this biotope was *Gladiolus hollandii* that was present in Plant Community 9. *Gladiolus hollandii* is listed as nt (not threatened anymore), therefore the low rating of 1.5. Declared weeds were low with a rating of 4. The carbon storage rating was very low (1.5) because of the low presence of trees. The total average score for vegetation in Biotope 3 was 13.00 with an average score of 2.60 (Table 6.4).

An average of 30 birds was present in this biotope with a rating of 1.5. No RDL species was recorded. The ratings for nesting and feeding guilds were 3.00 and 2.50, respectively. The total average score for birds in Biotope 3 was 7.00 with an average score of 1.75, the lowest score for the four biotopes (Table 6.4).

These areas were isolated because of the soil pockets on the exposed granite outcrops, but were intact with other biotopes such as the hills and valley (Biotope 2) therefore the networking rating of 2.00 (Figure 6.1 and 6.2). Human impacts does not affect this biotope and therefore the high rating 4, although plant community 8 was next to a walkway and was highly affected by humans and animals. Threats from adjacent areas were high with a rating of 2.00. The socio-economic and educational values were low with a rating of 2.50. The total score for the habitat evaluation in Biotope 3 was 10.50 and the average score was 2.63 (Table 6.4). The habitat evaluation contributes the most to the final score for the ecological value of this biotope.

The final score for the ecological value of Biotope 3 was 30.50, the lowest together with Biotope 1 that had an ecological value of 29.25. It was still a high evaluation value according to the ratings in Chapter 3. Management of these areas is important and any development has to be considered carefully.

Table 6.4: Evaluation of Biotope 3: Granite outcrops.

Section	Criteria	Biotope 3: Granite outcrops					
	Plant community	**8**		**9**		**Average**	
		Data value	**Rating value**	**Data value**	**Rating value**	**Data value**	**Rating value**
Vegetation	Spp richness (Avg)	32	2	46	3	39	2.50
	Indigenous spp (%)	97	4	94	4	96	4.00
	RDL (Total)	3	1	4	1	4	1.00
	Declared weeds (%)	3.1	4	2.3	4	2.7	4.00
	CO_2 storage (Value)	2	1	4	2	3	1.50
	Total vegetation rating						**13.00**
	Avg score						**2.60**
Birds	Spp Richness (Avg)	25	1	35	2	30	1.50
	Red data (Total)	0	0	0	0	0	0
	Feeding guild (Avg)	4	3	4	3	4	3.00
	Nesting guild (Avg)	5	2	8	3	7	2.50
	Total birds rating						**7.00**
	Avg score						**1.75**
Habitat	Networking (Value)	1	1	3	3	2	2.00
	Human impacts (Value)	8	4	4	4	6	4.00
	Adjacent land use (Value)	1	1	3	3	2	2.00
	Socio-economics (Value)	11	2	17	3	14	2.50
	Total Habitat rating						**10.50**
	Avg score						**2.63**
	Final score						30.50

6.3.4 Biotope 4: Grasslands

Only a few grassland biotopes are left in Mbombela. Biotope 4: grasslands consisted of four plant communities in Planning Area H within planning precinct H12 (Figures 3.3 and 3.5).

The investigated plant communities had 47 plant species with a rating of 3.00. Ninety seven percent of the plants were indigenous plant species with a score of 4. No RDL plant species was recorded. The rating for declared weeds was 4 as 2.1% of the vegetation in Biotope 4 was declared weeds. Because of the few tall trees present in this biotope, the carbon storage score was 2. The total vegetation score was 13.00 with an average score of 2.6, the second highest score for vegetation together with biotope 3.

The total number of birds was recorded as 30 with a rating of 2. No RDL bird species was recorded. The feeding and nesting guilds were rated as 3 and 4, respectively. The total evaluation score for birds was 9.00 with an average score of 2.25.

Although this biotope is connected with other biotopes, not many types of grasslands are left in Mbombela and the networking of the area was rated 3 (Figure 6.2). The human impact was low with a rating of 4 and the threats from adjacent areas were high with a rating of 2. The socio-economic and educational values had a rating of 2 because of the low presence of plants that

could be used by people in the area. The total habitat evaluation score was 11.00 with an average score of 2.75.

The final score of biotope 4 was 33, thus being of medium ecological value, but with higher scores than biotope 1 and 3. Grasslands are not common in Mbombela and the management of these areas is important to protect them from degradation and development.

Table 6.5: Evaluation of Biotope 4: Grassland

Section	Criteria	Biotope 4: Grassland	
	Plant community	**10**	
		Data value	Rating value
Vegetation	Spp richness (Avg)	47	3.00
	Indigenous spp (%)	97	4.00
	RDL (Total)	0	0.00
	Declared weeds (%)	2.1	4.00
	CO_2 storage (Value)	4	2.00
	Total vegetation rating		**13.00**
	Avg score		**2.60**
Birds	Spp Richness (Avg)	30	2.00
	Red data (Total)	0	0.00
	Feeding guild (Avg)	4	3.00
	Nesting guild (Avg)	10	4.00
	Total birds rating		**9.00**
	Avg score		**2.25**
Habitat	Networking (Value)	3	3.00
	Human impacts (Value)	8	4.00
	Adjacent land use (Value)	2	2.00
	Socio-economics (Value)	15	2.00
	Total habitat rating		**11.00**
	Avg score		**2.75**
	Final score		33.00

6.4 Conclusion

The EMF (2006) did an evaluation on vegetation and made a broad recommendation with regard to development and the prevention of destruction of natural resources in open spaces and will be discussed in Chapter 7. With the three criteria: vegetation, birds and habitat, the current study indicated the high importance of conservation of the natural open spaces in Mbombela. Natural open spaces of Mbombela are rated with an ecological value of medium to high in the urban context, according to the evaluation criteria used in the current study. Biotopes with a high final score had a high contribution from the vegetation criteria followed by the habitat criteria. It is important to have a well developed management plan to manage vegetation in open spaces to have a high ecological value and biodiversity (Table 6.6).

Biotope 2 in this study can be regarded as having a high ecological value. The other three biotopes have a medium ecological value, due to the bad vegetation conditions.

Although the scaling used in this study is generally regarded as subjective, two sets of criteria namely vegetation (Chapter 4 and 5) and birds (Chapter 5) used quantitative (measurable and repeatable) characters. It is only the habitat criteria that were based on qualitative observations. More research is needed on the quantification of characters such as socio-economics, human impacts and adjacent land use.

Biotope 2 had the highest final score of 37.33, where the vegetation criteria contribute the most with an average score of 3.13 (table 6.6). Biotope 2 have the most RDL plant species and one RDL bird species compared to the other biotopes. Biotope 1 had the lowest final score with 29.25 (Table 6.6). Part of biotope 1 is the Crocodile River Greenbelt Initiative which will be discussed in chapter 7. Despite the management and conservation efforts of the Municipality, Biotope 1 had the lowest percentage of indigenous plant species (Table 6.2) compared to the other biotopes.

Table 6.6: Evaluation values of Plant Communities and Biotopes in Natural Open Spaces of Mbombela, using criteria from Table 3.5.

Section	Criteria	Biotope 1 Rivers and streams						Biotope 2 Hills and valleys					Biotope3 Granite outcrops				Biotope 4 Grasslands
	Plant Community	**1**	**2**	**3**	**4**	**Tot**	**Avg**	**5**	**6**	**7**	**Tot**	**Avg**	**8**	**9**	**Tot**	**Avg**	**10**
Vegetation	Spp richness (Avg)	2	2	2	3	9	2.25	3	3	4	10	3.33	2	3	5	2.50	3.00
	Indigenous spp (%)	4	3	3	4	14	3.50	4	4	4	12	4.00	4	4	8	4.00	4.00
	RDL (Total)	0	0	1	1	2	0.50	1	1	1	3	1.00	1	1	2	1.00	1.00
	Declared weeds (%)	2	1	1	3	5	1.75	4	4	4	12	4.00	4	4	8	4.00	4.00
	CO_2 storage (Value)	4	2	3	3	12	3.00	4	3	3	10	3.33	1	2	3	1.50	2.00
	Total vegetation score	**8**	**6**	**7**	**11**	**32**	**11.0**	**12**	**12**	**13**	**37**	**15.67**	**11**	**12**	**23**	**13.00**	**13.00**
	Average rating						**2.20**					**3.13**				**2.60**	2.60
Bird	Spp Richness (Avg)	4	2	2	2	10	2.50	4	2	3	9	3.00	1	2	3	1.50	2.00
	Red data (Total)	0	0	0	0	0	0	1	0	0	1	0.33	0	0	0	0.00	0.00
	Feeding guild (Avg)	3	3	2	3	11	2.75	3	3	3	9	3.00	3	3	6	3.00	3.00
	Nesting guild (Avg)	4	3	4	3	14	3.50	4	3	4	11	3.67	2	3	5	2.50	4.00
	Total bird score	**11**	**8**	**8**	**8**	**35**	**8.75**	**12**	**8**	**10**	**30**	**10.00**	**6**	**8**	**14**	**7.00**	**9.00**
	Average rating						**2.19**					**2.50**				**1.75**	2.25
Habitat	Networking (Value)	3	4	3	2	12	3.00	3	3	2	8	2.67	1	3	4	2.00	3.00
	Human impacts (Value)	3	1	2	3	9	2.25	4	3	3	10	3.33	4	4	8	4.00	4.00
	Adjacent land use (Value)	3	1	1	2	7	1.75	3	2	2	7	2.33	1	3	4	2.00	2.00
	Socio-economics (Value)	2	3	2	3	10	2.25	4	3	3	10	3.33	2	3	5	2.50	2.00
	Total habitat score	**11**	**9**	**8**	**10**	**28**	**9.50**	**14**	**11**	**10**	**25**	**11.67**	**8**	**13**	**16**	**10.50**	**11.00**
	Average rating						**2.38**					**2.92**				**2.63**	2.75
	Final score						**29.25**					**37.33**				**30.50**	**33.00**

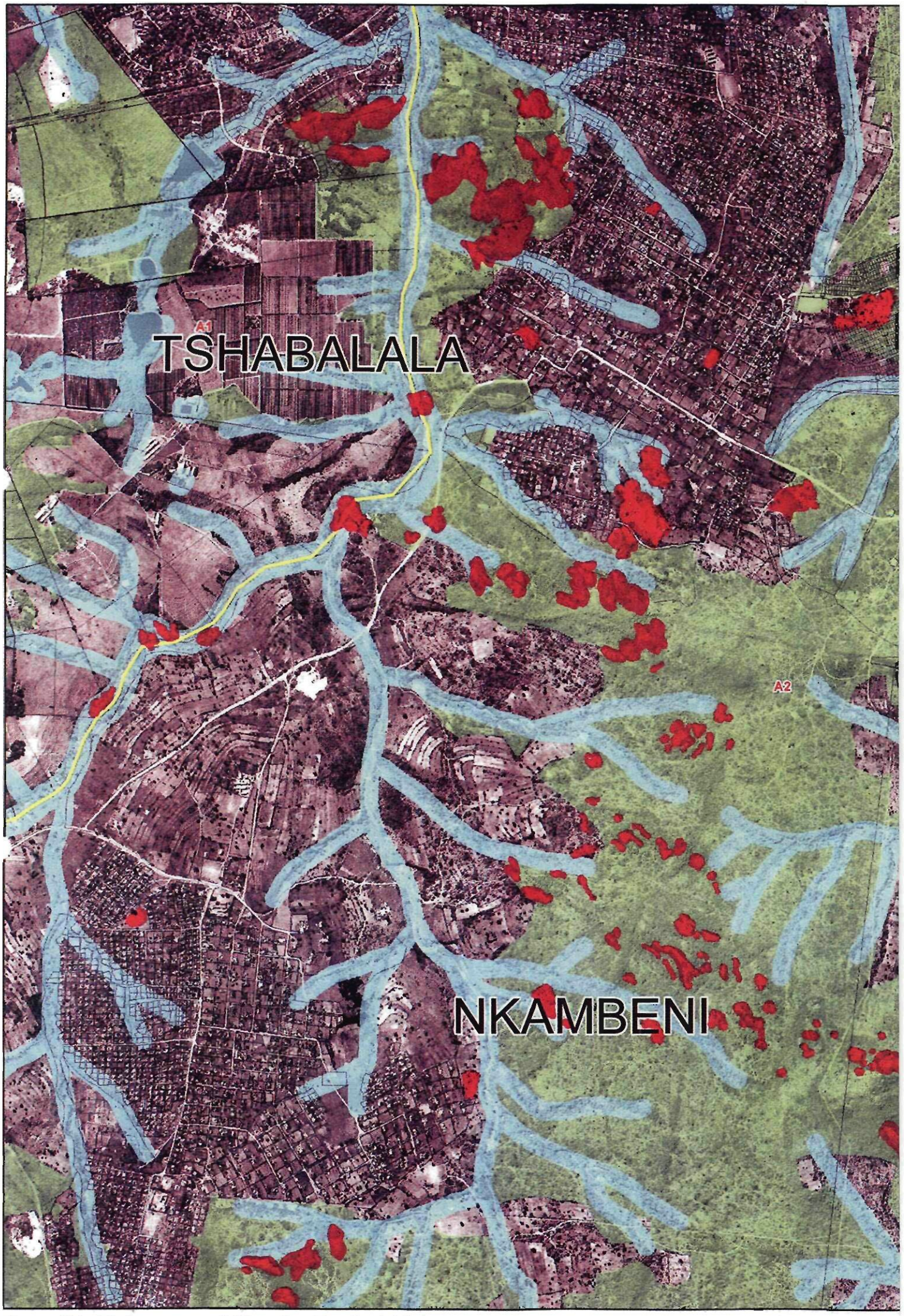


Figure 6.1: Biotope map of Planning Precinct A2

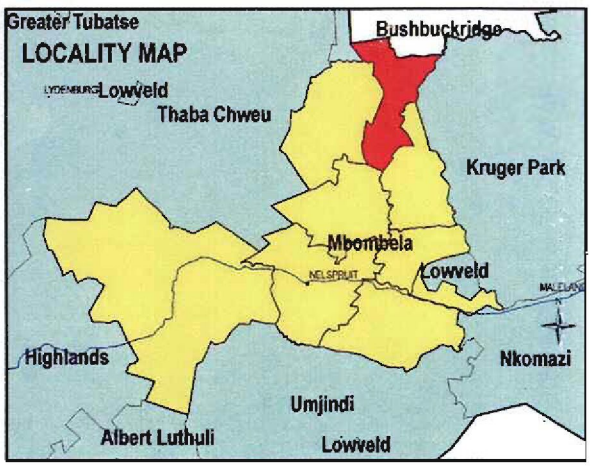


PLANNING AREA A WITH 3 BIOTOPES

Legend

- Hills and valleys: Biotope 2 High Ecological Value
- Granite outcrops: Biotope 3 Medium Ecological Value
- Rivers and streams: Biotope 1 Medium Ecological Value

SCALE: 1:24,744



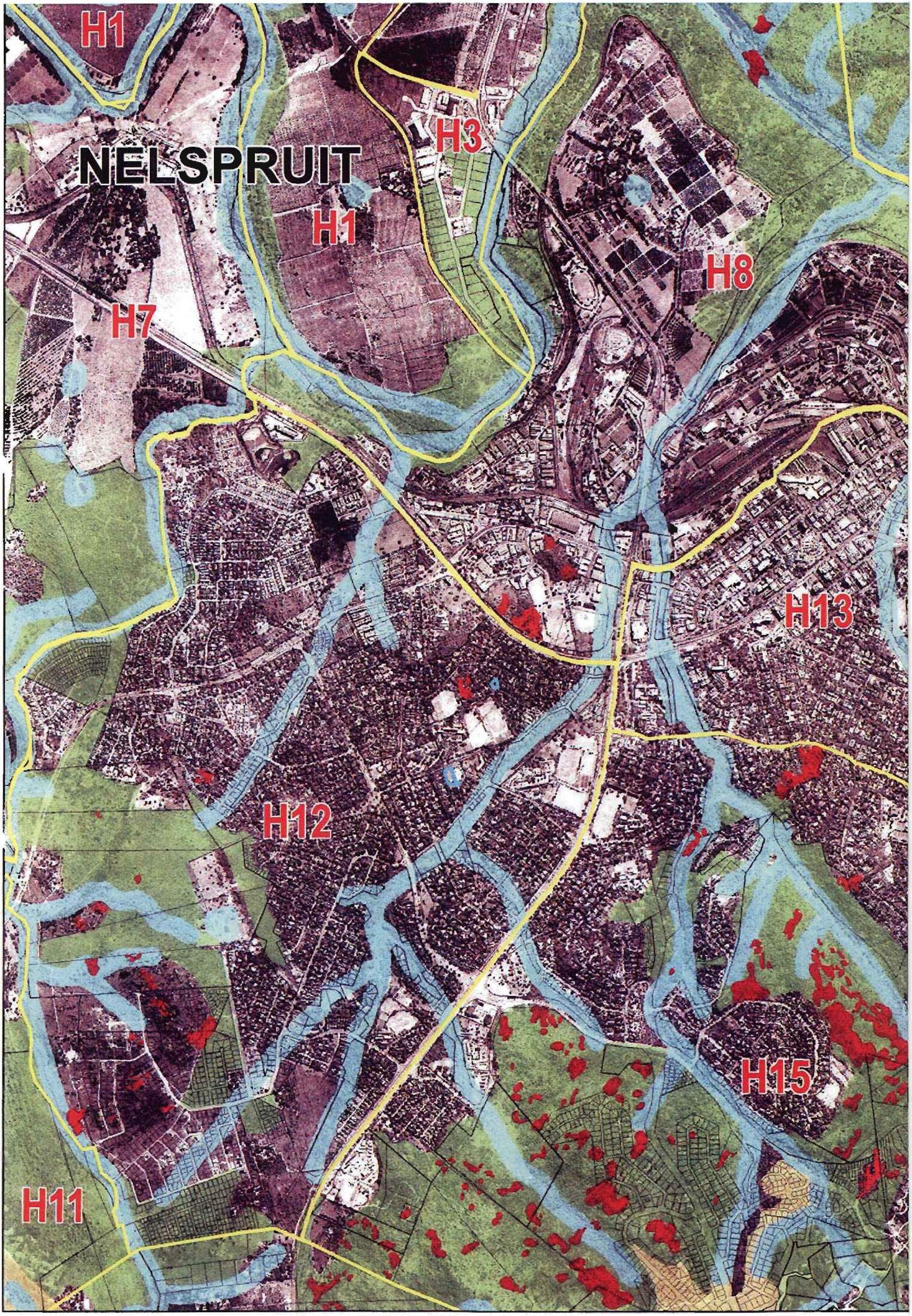
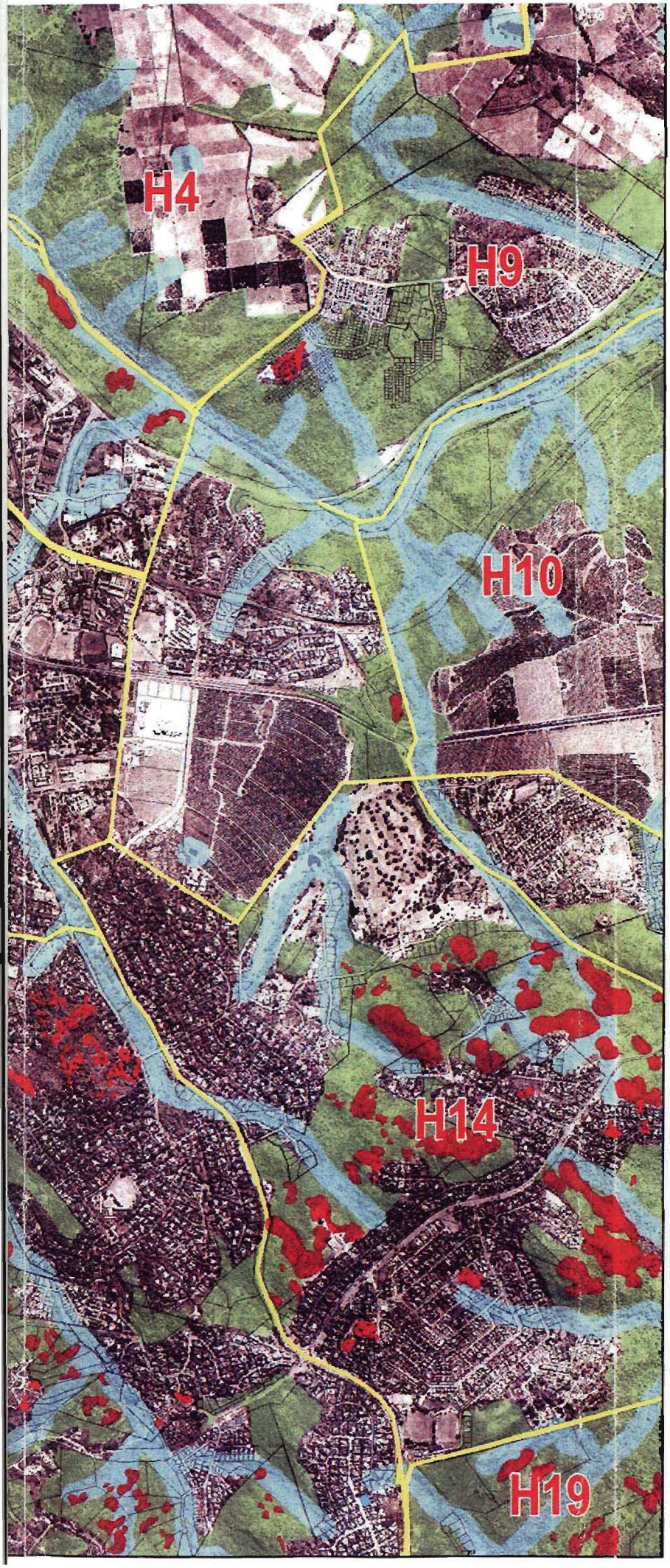


Figure 6.2: Biotope map of Planning Precinct H



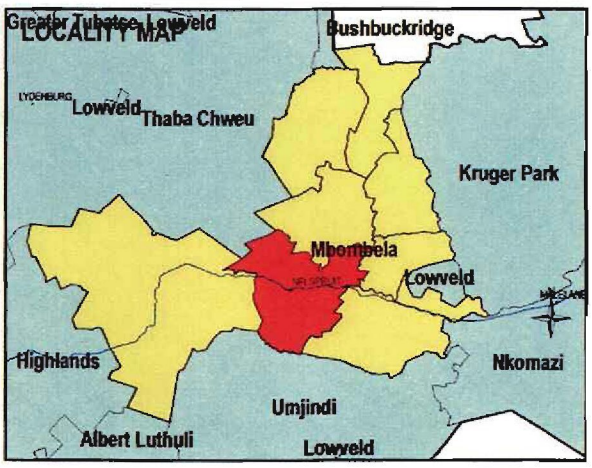
PLANNING AREA H WITH 4 BIOTOPES

Legend

- Hills and valleys: Biotope 2 High Ecological Value
- Granite outcrops: Biotope 3 Medium Ecological Value
- Grasslands: Biotope 4 Medium Ecological Value
- Rivers and streams: Biotope 1 Medium Ecological Value

SCALE: 1:24,744

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CHAPTER 7



Environmental Policy perspective

CHAPTER 7
ENVIRONMENTAL POLICY PERSPECTIVE

7.1 Introduction

The Development Facilitation Act (67/1995) provides development principles for a better urban structure. Physical, economic, social, institutional and environmental aspects should interact with each other for a holistic approach to urban development. The Integrated Development Plan (IDP), which local authorities are obliged to prepare under the Local Government Municipal System Act (32/2000), is important for spatial planning (Glazewski, 2000). The purpose of the IDP, 2005/2006 is to promote the integration of the physical, social, economic and institutional components of planning and to link these to a management and implementation structure for the area of jurisdiction. Mbombela Local Municipality (MLM) adopted the State of Environment Report (Naidoo *et al.,* 2003), the Integrated Waste Management Plan (2005), the Spatial Development Framework (Laduma, 2006) and the Draft Land Use Management Framework (Sisonke Development Planners, 2006) as part of the IDP.

The aim of this chapter is to summarize the Mbombela State of the Environment Report (SoER, 2003), Environmental Management Framework (EMF, 2006), Draft Open Space Policy (2005), Crocodile River Greenbelt Initiative Policy (2004) and the EIA Guideline document.

7.2 The Mbombela State of the Environment Report (SoER).

The State of the Environment Report is a decision-making and reporting tool which provides information and trends on the environmental state of a specific area or region. The SoER, 2003 of Mbombela Local Municipality was based on the requirements of Agenda 21 and the IDP (2002). The SoER (2003) described the status quo of Mbombela's environment and addressed the environmental changes. It will be updated in 2008 to determine trends in the state of the environment. The indicators used for evaluation of the environment were terrestrial, water and cultural/historical resources, air quality, land uses, socio-economics, infrastructure, tourism and environmental governance. A brief summary of the indicators will be discussed hereafter.

A wide altitude range (Figure 2.3) creates a wide range of ecological conditions. According to Naidoo *et al.* (2003), three sensitive habitat units were present in Mbombela: Natural grasslands (44%), natural forests (7.5%) and wetlands (0.3%) (Figure 7.1). Satellite imagery (Spot 4), taken in 2003, was used to assess the extent of large habitat units within Mbombela that are considered ecologically sensitive. Riparian (river) zones are also ecologically important, sensitive habitats, but these were too narrow to be quantified from the available satellite images.

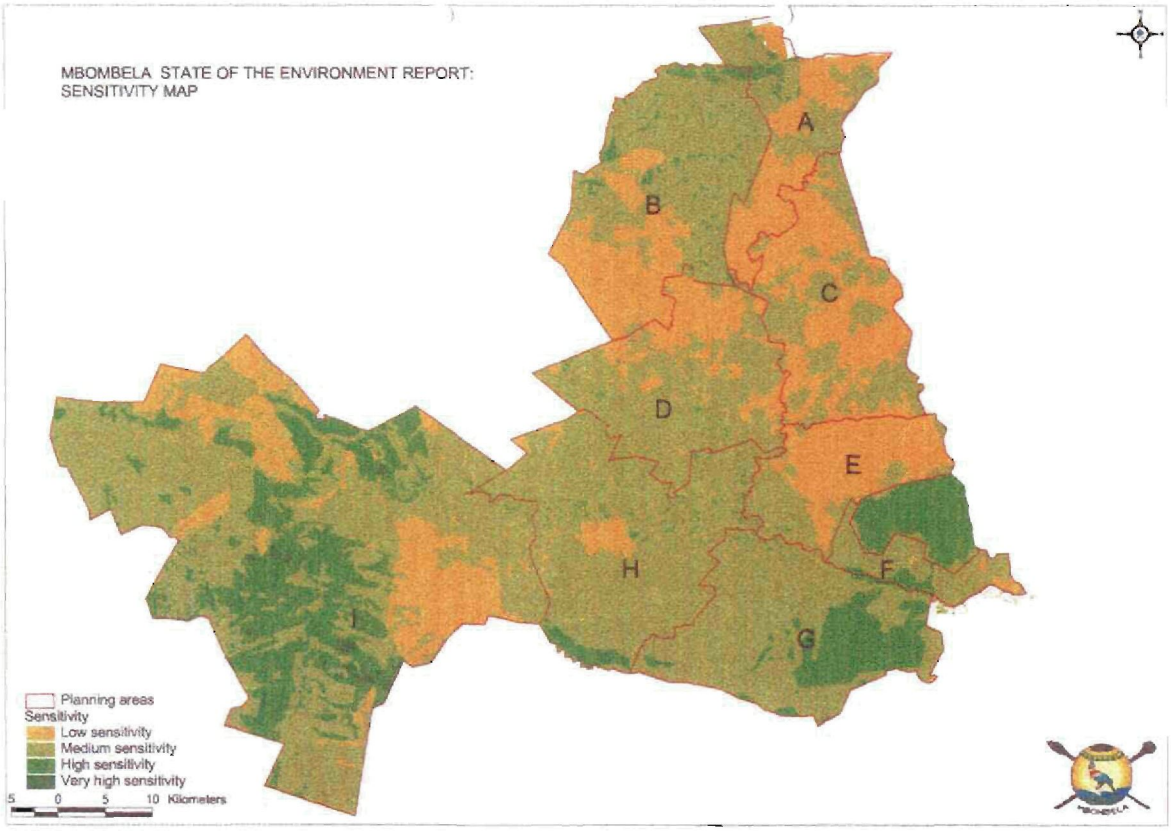


Figure 7.1: Sensitivity map (Naidoo *et al.*, 2003)

The indicators for Terrestrial Resources were sensitive habitats, conservation areas, sensitive terrestrial biota, alien vegetation and target species such as population status of locally extinct, endangered, vulnerable, rare and indeterminate species. Plant Red Data species in the SoER, 2003 were based on Mpumalanga Parks board Biobase of Emery (quoted by Naidoo, *et al.*, 2003).

Plant and animal populations are threatened due to increasing fragmentation of habitats, uncontrolled burning, the spread of alien vegetation, demand for collector species (ferns and cycads) and the use of vegetation for daily livelihood (firewood, medicinal uses, furniture and curios). Deterioration of soil conditions, including erosion, soil acidification and reduced soil fertility, is also a problem in Mbombela. More than 20% of land in Mbombela is formally protected, mostly as voluntary conservancies. The implementation of a development plan that integrates basic conservation principles and the needs of the rural inhabitants could enhance the terrestrial resources.

The natural water resources in Mbombela are the Crocodile River and Elands River in Nelspruit and the Sabie River and Northern Sand River in Hazyview, as indicated in Chapter 2. The main water source is the Kwena Dam outside the municipal boundary near Lydenburg. Groundwater

supplies within the area are limited and unsuitable for providing bulk supplies. The rate and type of future development in Mbombela are linked to the quantity and quality of available water supplies.

Agriculture and industrial expansion, as well as the associated pollution, alien vegetation and sanitation facilities, contribute to the deterioration of water resources in Mbombela. Soil erosion, sand mining and poor storm water management are a problem in some areas. Other causes of water resource degradation are washing in rivers, solid waste disposal, manganese, forestry activities and effluent from paper mills and trout farms. Water resources are stressed by over-utilization, increasing encroachments of wetland development, siltation and pollution from domestic and industrial effluents.

According to the South African Scoring System (SASS) 4 evaluation, 40% of rivers and streams within Mbombela are in good health (Class B) and 9% in very poor conditions (Classes E and F) (Figure 7.2). Moderate weed infestation occurs in rivers in the Mbombela area. A development plan which includes conservation of wetlands as well as environmental education will enhance water quality.

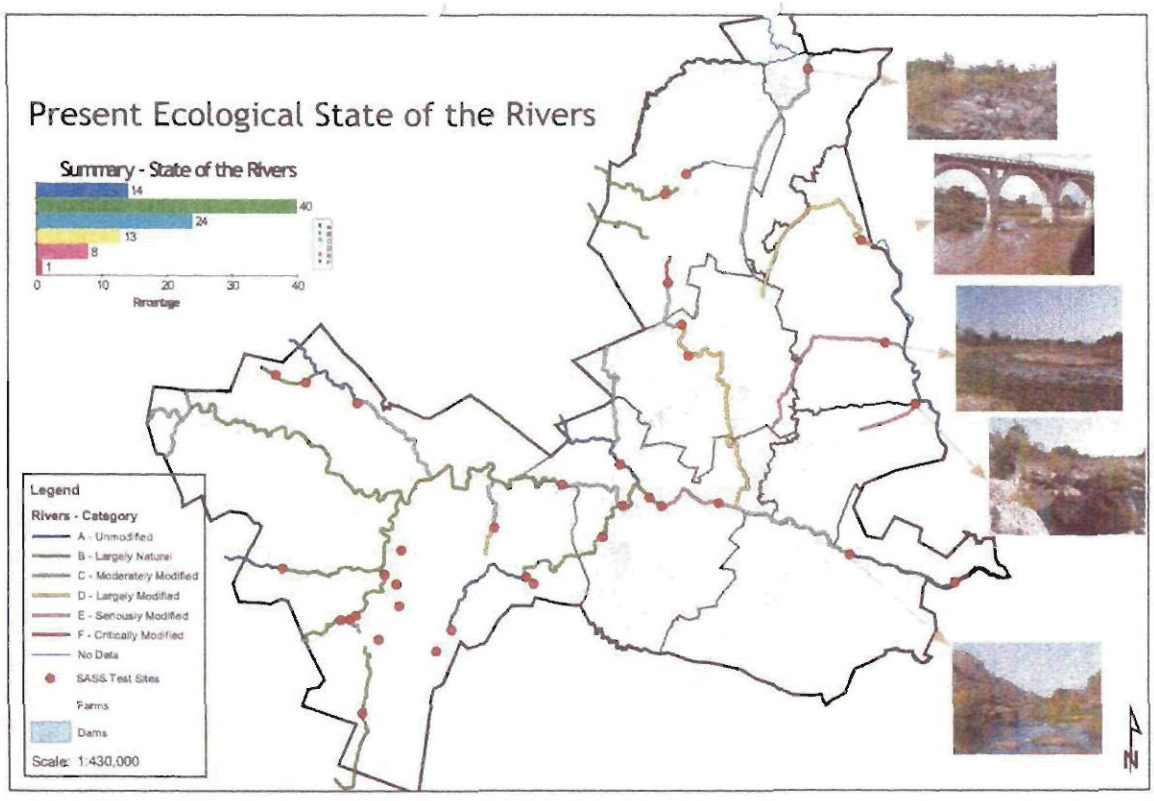


Figure 7.2: States of rivers and streams in Mbombela (SoER, 2003)

The air quality of Mbombela is impacted by outside activities such as electricity generation in Mpumalanga and activities within the vicinity of Mbombela that include industrial emissions, vehicle emissions along the N4 and smoke from domestic wood, sugarcane and waste burning. The analysis of existing MLM data indicates a marked seasonal variance with high readings during the winter. The smoke levels within Nelspruit are low with an annual average of 3.3S/m^3 for 2002, while the highest levels were recorded during May and June.

The burning of fossil fuels and wood contribute significantly to air pollution and the potential trends in air quality variations can be determined by analyzing household energy use with reference to the type of fossil fuels utilised. A high percentage of Mbombela's population still use forms of energy other than electricity for cooking, heating and lighting. The main potential contributors to air pollution would be burning of wood, coal and animal dung, where coal and animal dung are used by less than 1% of the households for cooking and heating. Twenty one percent of households burn wood for cooking and 36% for heating.

The expansion of electricity reticulation to supply those currently without electricity and the promotion of the use of electricity should be prioritized. The utilization of wood as energy source is a serious problem because it contributes to air pollution and reduction in tree numbers. See discussion of carbon storage ability of trees in Chapter 6.
Mbombela has a variety of cultural resources, including historical buildings, monuments and rock art sites. Information on the status of cultural or historical resources is limited, although some of the sites have a high tourism potential. Cemeteries are an important cultural resource in MLM. The provision of formal, cost effective cemeteries is a serious issue because of the effect of HIV/Aids and the associated high mortalities. A lack of cemeteries could have a significant detrimental effect on the environmental health of communities. Although it is important to promote the value of cultural heritage resources, this information is not used in biotope mapping.

Any use of land has impacts on the natural environment. Both the extent and the intensity of the land use define the severity of the impact. The SoER (Naidoo *et al.,* 2003) quantified and qualified the effect that different types of land uses have on a natural habitat. The land use was divided into six themes for discussion in the SoER (2003), being Human Settlement, Open Space (green areas), Industrial, Agriculture, Forestry and Mining.

The critical socio-economic factors in Mbombela are poverty, unemployment and the health status of the population. The majority of the people still live in severe poverty and inequality with most of the households lacking adequate services. The average income is low and is essentially spent on food and travelling to work. Unemployment is high in Mbombela (64%) and

food security is low. The highest level of unemployment (75 %) is in Planning Area A, while the lowest (13 %) is in Planning Area B. Planning Area H has an unemployment rate of 38%.

The population growth rate and increased waste production put pressure on the environment as well as on the management of waste by Mbombela Local Municipality. According to the SoER (Naidoo *et al.,* 2003), approximately 50m^3 of illegal waste was recovered monthly by Mbombela. Twenty-six percent of Mbombela has weekly refuse removal. Planning Area H has weekly refuse removal in more than 60% of the region, while Planning Area A has less than 10% coverage. Inadequate water supply is a critical issue in Mbombela and in some areas the quality of water is a concern. An estimated 68% of households have access to water within 200m from their dwellings. A minimum of 71% of households has electricity and the rest make use of fossil fuel or wood for energy supplies. The highest portion of energy use for lighting is in Planning Area H and the lowest is in area G. Planning Areas A, B, C, D, G and I are areas where the dependence on wood burning for heating is higher than 35%.

Traffic passing through on the N4 contributes to the traffic volume in Mbombela. More than 6000 vehicles travelled through Mbombela on the N4 daily during 2002. Of these, 15.5% were heavy vehicles. Existing transportation infrastructure is under pressure due to the increase in traffic demand. The overall conditions of the road network are considered to be poor, especially in the rural areas. The total length of roads in Mbombela is approximately 2512 km, of which 374 km is paved and 2138 km is unpaved or gravel roads. Mbombela has a vehicle population of 69 657 and the theoretical traffic volume is 27.7 vehicles per km for the total length of the roads in the area.

The SoER (Naidoo *et al.,* 2003) gives an overview of the state of the environment in Mbombela based on indicators and concerns raised by stakeholders in workshops during 2003. Broad scale investigations like the data used for the SoER can have an influence on ecological patterns that can override the local effects (Wiens, 1989). Rahbek (2005) indicated that large-scale species richness patterns assumed implicitly that patterns and mechanisms were scale invariant and that scale effects can influence the perception of patterns and processes. It is necessary to do this type of investigations on a finer scale meaning that natural open spaces need to be studied specifically.

7.3 Draft Environmental Management Framework (EMF).

Mbombela Local Municipality (MLM) has identified the need for an environmental management decision-support tool within which other instruments can be managed, e.g. Environmental Impact Assessment (EIA). The EMF (Strategic Environmental Focus, 2006) informs other managing tools such as the Integrated Development Plan (IDP) and Spatial Development

Framework (SDF) with regard to environmentally sensitive and conflicting land uses. This is to ensure that development in MLM occurs in a sustainable manner and keeps in line with the principles of National Environmental Management Act (NEMA) (107/1998). The EMF (Strategic Environmental Focus, 2006) is a framework of spatially represented information derived from parameters such as ecology, hydrology, geology, infrastructure and services. The purpose is to pro-actively identify potential conflict between development proposals and critical/sensitive environments and was completed after the current study of biotope mapping started in 2003.

The EMF (Strategic Environmental Focus, 2006) included maps of the geographical area that specified the attributes of the environment and included the sensitivity extent, inter-relationship and significance of those attributes. It identified parts in the area to which those attributes are related. The EMF (Strategic Environmental Focus, 2006) also stated the conservation status and the environmental management priorities of an area. It indicated the activities that would have a significant positive impact as well as activities that would be undesirable in a specific area. It covered the SDF of 2005, which integrates the environmental layer with social and economic considerations. The directives of the SDF (2005) were used as input for the EMF (2006) to describe the desired and undesired land uses and activity zones.

The EMF (Strategic Environmental Focus, 2006) did an Importance Rating (IR) of Mbombela by the integration of the baseline information layers and included current policies, participation and contributions from present stakeholders as well. The baseline information was transformed into secondary information through a series of sensitivity analyses whereby the importance of various environmental features was rated in order to establish the development suitability of land parcels. The most significant environmental features that require careful planning and management in the development of both rural and urban environments include, according to the EMF (Strategic Environmental Focus, 2006):

- The occurrence and distribution of Red Data fauna and flora species
- Sensitive habitats and natural open space connectivity
- Surface hydrological features, including wetlands, pans, rivers etc.
- Surface water and groundwater quality and quantity
- Surface water and groundwater quantity
- High potential agricultural land
- Natural and cultural heritage sites
- Topography
- Soil characteristics
- Geotechnical constrains
- Air quality

With the environmental sensitivities of the municipality quantified and mapped, an Importance Rating (IR) system was applied. The degree to which an area was considered sensitive was rated by a specialist in the relevant field (ecologist, geomorphologist, etc). Areas were reclassified into three categories of sensitivity i.e. High, medium or low. By applying this weighting system, certain areas were given priority over others. Emphasis was placed on those areas which need to be managed and protected as well as to highlight specific aspects of the municipality that must be given careful consideration when approving development applications and planning for future development within the MLM.

Various criteria were selected to determine the Importance Ratings (IR) of land parcels in the MLM. Importance rating criteria of agricultural, geotechnical, heritage and industrial factors were used for the importance rating in the EMF (2006), but will not be discussed because it is not applicable for this current study. The following criteria were used for the IR in the EMF (Strategic Environmental Focus, 2006) and will be directly quoted from the EMF (2006) for this current study:

- **Ecological Importance Rating (EMF, 2006):**

The ecological sensitivity was determined by a number of factors, the Mpumalanga Biodiversity Conservation Plan (C-Plan), habitat types, Red Data fauna and floral species presence, topographical features, the underlying geology and wetlands. The C-Plan is a comprehensive environmental inventory and spatial plan development of Mpumalanga Province based on existing information. (Lotter & Ferrar quoted by Strategic Environmental Focus, 2006). A specialist ecologist assigned values to ecological importance, species richness, natural vegetation, ability to regenerate in disturbed environment, level of disturbance and possible occurrence or sighting of Red Data species. The categories were classified as being of very high, high, medium to high, medium and low importance.

- **Water Quality and Quantity Importance Rating (Strategic Environmental Focus, 2006):**

Water quality and quantity were assessed separately to determine the risks to the environment and development as a result of the current state of the water resources. Both water quality and quantity have major implications for development. Water quality constraints are related to the present ecological state of the river system, including the level of pollution (TDS, ions, pH, etc). Surface water and groundwater yield potential were both considered in the calculation of water availability. The water quality and quantity constraints in the MLM have been rated at catchments levels in terms of high, medium and low risk areas.

Directives for agricultural, heritage, infrastructure and geological constraints can be found in the EMF (Strategic environmental Focus, 2006). General environmental directives in terms of

ridges, alien vegetation, open spaces and ecological corridors, compiled for the EMF (2006), will be quoted and are as follows:

- Ridges
  - No further development should take place on ridges with a slope greater than 16%.
  - For all proposed listed developments on ridges with a slope of ≥9% that fall within the "protected area", "very high", "high" and "medium to high" IR categories, an environmental impact assessment is required.
  - No septic tanks will be permitted and adequate water supply is required for fire protection.
- Alien vegetation

  All developments must ensure the removal of alien vegetation as categorised in terms of the Conservation of Agricultural Resources Act (43/1983) and/or in the National Environmental Management Biodiversity Act (10/2004)
- Open Spaces

  The international standard for social open spaces is 2.4 ha per 1000 members of a population. Residents bordering all open spaces must ensure that their gardens are indigenous and kept as natural as possible to provide a buffer for the open space. No solid fencing will be allowed on the communal boundary with open spaces. Fences should allow access for species movement and linkages with other open spaces. Development applications for major roads, railway lines and pipelines must demonstrate, through alternative alignments, the connectivity of the open space through which they transect.
- Ecological corridor

  Where development is unavoidable, the developer must demonstrate how the development will impact on ecological connectivity.

7.3.1 Ecological importance for Planning Area A

The ecological importance areas of Planning Area A are indicated in Figure 7.3 and show the following categories (Strategic Environmental Focus, 2006):

- Very High Ecological Importance

  Incorporation of these areas into the formally protected areas system through the National Environmental Management: Protected Areas Act (57/2003). Land use for development or construction requires full EIA procedures.

- High and Medium to High Ecological Importance

  Limitation of permissible land uses and no permitting for increase of intensive livestock production. Should development be unavoidable, such land should be sufficiently dispersed. Provision of compensatory offsets of biodiversity loss should only be considered at an exchange rate of at least 200% for high ecologically important sites and

100% for medium to high sites. Landscape plans must be included. The 1:100 year flood line must be determined and indicated on the site development plan. No alterations of the riparian vegetation will be permitted. An aquatic ecological study is also required with an environmental management plan. Water use licences are required from DWAF for the storage and use of water. Irrigation-crop agriculture and industries must be limited in areas identified as high risk.

- Medium and Low Ecological Importance
  Although biodiversity issues are of least concern, management must be considered on catchments. Land use planners must consider socio-economic efficiency, aesthetics and the sense of place in making decisions regarding development.

7.3.2 Ecological importance for Planning Area H

The areas of Planning Area H of ecological importance are indicated in Figure 7.4 and show the following categories (Strategic Environmental Focus, 2006):

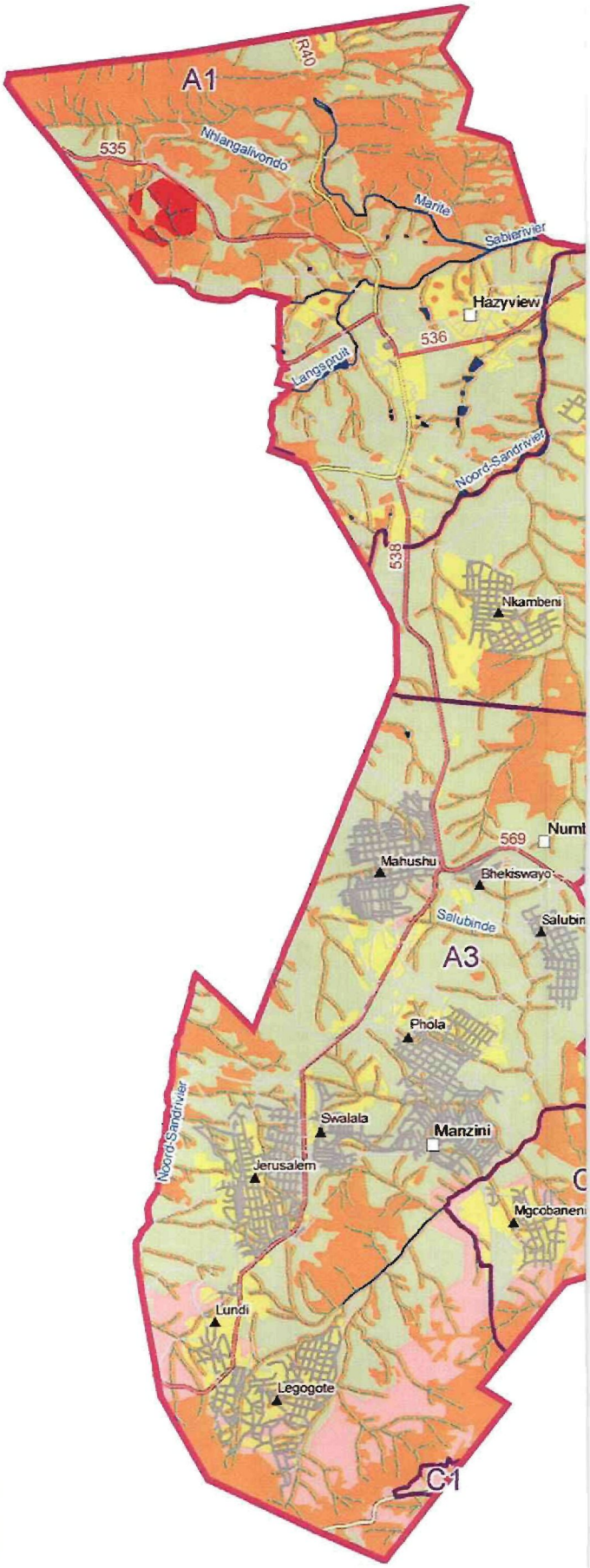
- Very High Ecological Importance
  (as in Planning Area A)

- High and Medium to High Ecological Importance
  (as in Planning Area A)

- Medium and Low Ecological Importance
  (as in Planning Area A)

The EMF (2006) is a decision-making support tool and has to be implemented by the authorities, developers and consultants. The ecological sensitivity was determined by, among others, the draft Mpumalanga Biodiversity Conservation Plan (C-Plan), environmental inventory and spatial plan developed for the Mpumalanga Province. The scale used for Important Ratings (IR) was too broad to mitigate urban effects on the natural open spaces in the different Planning Areas. Directives for development and planning by the EMF (2006) were based on large scale data and therefore most urban areas had low sensitivity.

PLANNING AREA A

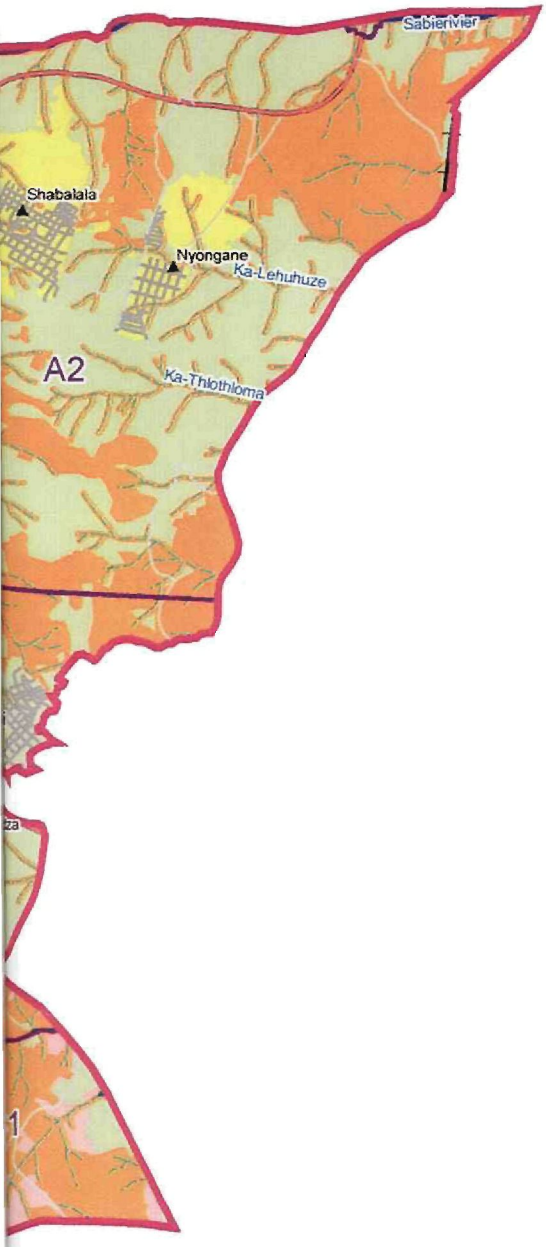


Sources of Information:
Orientation data: DEAT 2001/CDSM 1996
Towns: Municipal Demarcation Board 2003
Ecological IR: SEF/SEFGIS 2006

Coordinate Information, Geographic, Hartebeesthoek1994 Datum

ECOLOGICAL IMPORTANCE RATING OF THE MBOMBELA LOCAL

Figure 7.3: Ecological importance rating of Planning Area A (Strategic Environmental Focus, 2006)



Planning Area A

- Planning Area A
- Main towns
- Places
- Precincts
- Railways
- National route
- Arterial route
- Main road
- Secondary road
- Street
- Other access road
- Perennial river
- Non-perennial river
- Man-made dams

Ecological IR for planning area A:

- Very High (0.39 %)
- High (41.45 %)
- Medium to High (4.09 %)
- Medium (43.67 %)
- Low (10.41 %)

N

1:125,000

0 1.25 2.5 5 km

MUNICIPALITY PER PLANNING AREA

Prepared by:

Prepared for: May 2006

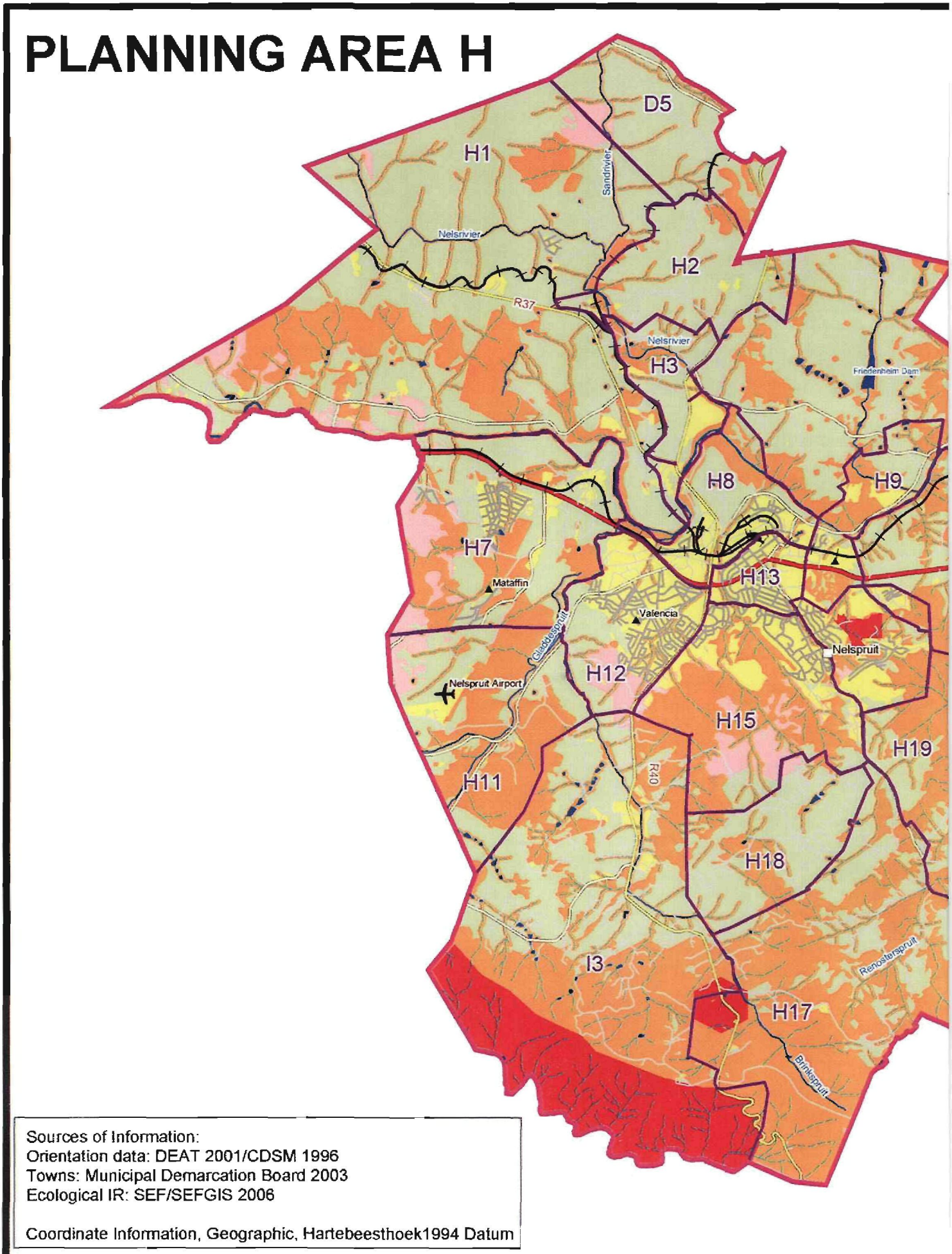
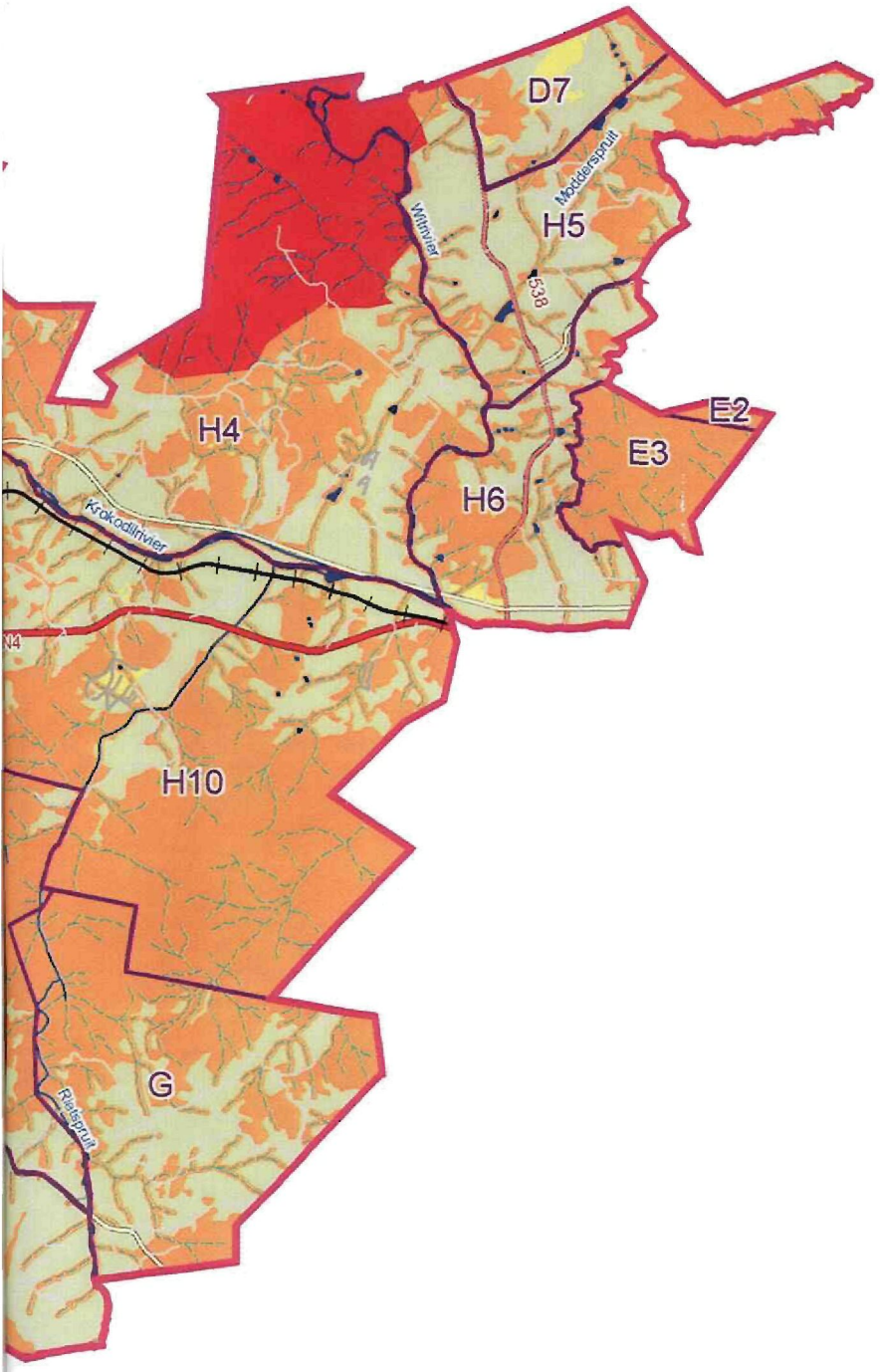


Figure 74: Ecological importance rating of Planning Area H (Strategic Environmental Focus, 2006)



Planning Area H

- Planning Area H
- Main towns
- Places
- Airport
- Precincts
- Railways
- National route
- Arterial route
- Main road
- Secondary road
- Street
- Other access road
- Perennial river
- Non-perennial river
- Man-made dams

Ecological IR for planning area H:

- Very High (6.12 %)
- High (46.29 %)
- Medium to High (2.23 %)
- Medium (39.42 %)
- Low (5.93 %)

N

1:115,000

0 1.25 2.5 5 km

L MUNICIPALITY PER PLANNING AREA

Prepared by:

Prepared for:

May
2006

7.4 Crocodile River Greenbelt Initiative Policy.

The Crocodile River Greenbelt Initiative Policy (2004) compiled by Mbombela Local Municipality stated that the Crocodile River forms a sustainable edge on the northern side of Nelspruit (Figure. 7.5 and 7.6) and supports a wide variety of fauna and flora. Because of the environmental importance of the Crocodile River, it could be included in the Gorge Conservancy. The rapid growth of Nelspruit, its associated industrial development, informal settlements and the intensive irrigation along the banks of the Crocodile River contribute to the deterioration in downstream river water quality. Developers and investors indicated the necessity of a general policy for the Crocodile River Area and the purpose of this document is the more detailed elaboration of the planning framework, the State of the Environment and proposals identified in the Integrated Spatial Framework for the Western Nelspruit Development Zone (Planning Area H).

The conservation of this area will allow minimum development which may have a negative environmental impact. This document provides the basis for the Council to evaluate development proposals for the Crocodile River Greenbelt Area. This policy allows for a range of development proposals and is a guiding document for an individual development in the Crocodile River Greenbelt Area. It provides the basis for establishing the desired physical characteristics of the area. The policy elaborates the Spatial Development Framework and defines the broad parameters expected of any proposal in the Crocodile Greenbelt Area.

The Crocodile River Area should be developed and managed to enhance environmental awareness by means of educational trails, centres and exhibition activities. Conservation of the Crocodile River Area is the ultimate goal in this area, although planning must also address the use of land that is to a certain extent suitable for limited development. This area is ideal for eco–tourism and nature-orientated developments. According to this document, this area is suitable for passive and active recreation developments as well as residential development. The Spatial Development Framework indicates that commercial land uses could be located on the fringe of the Crocodile River Area. The principle of "core – buffer/transition area" must be applied to all developments on the fringe of the Crocodile River Area

The Crocodile River Greenbelt Policy has placed prohibitions on some actions in general, such as some uses, waste issues and the uses of vehicles in Open Spaces. It described the protection of animals and vegetation within the Crocodile River Greenbelt area. The main purpose of these prohibitions is to protect certain open spaces from degradation, disturbances and loss of biodiversity.

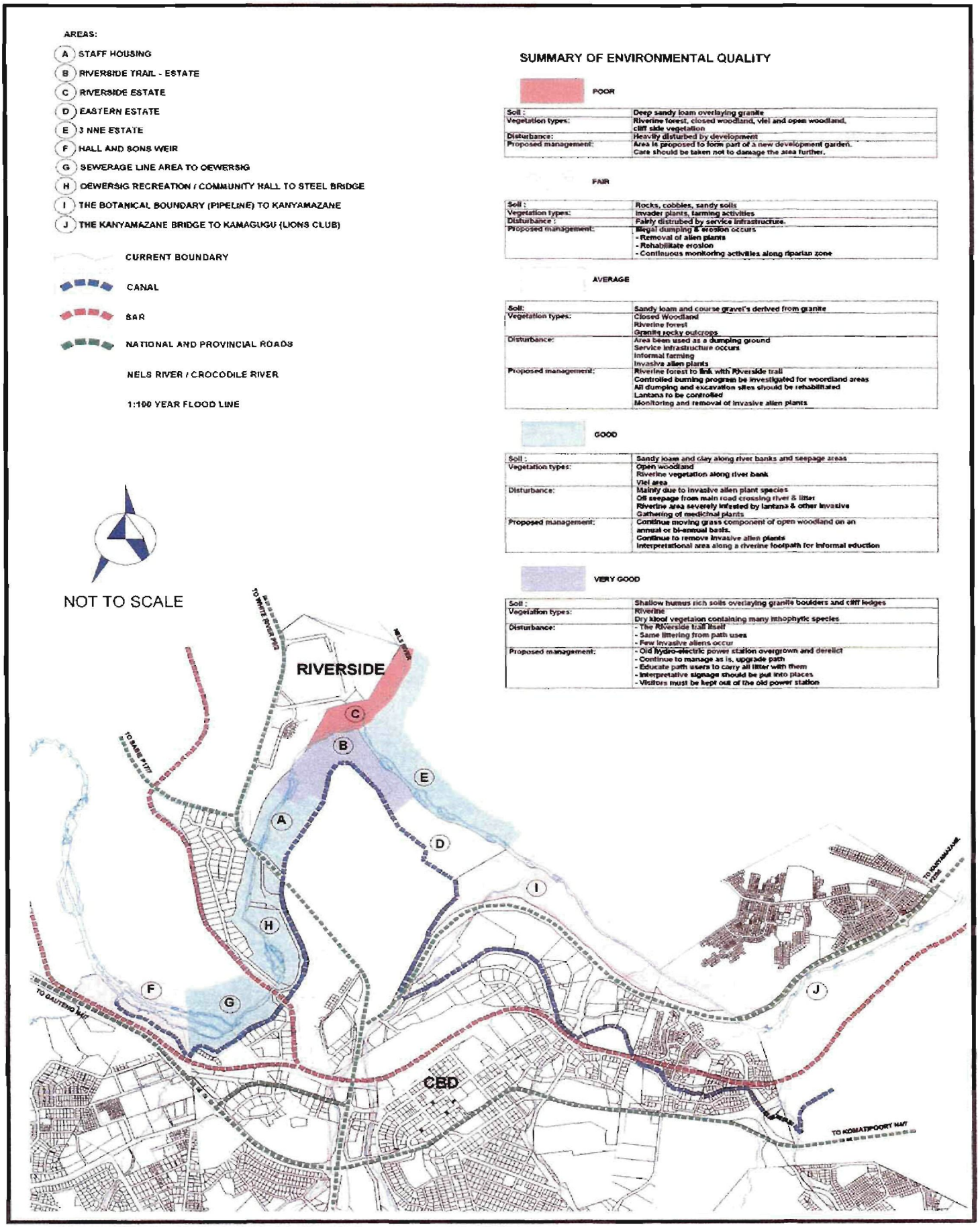


Figure 7.5: Summary of Environmental quality of the Greenbelt Area (Anon, 2004)

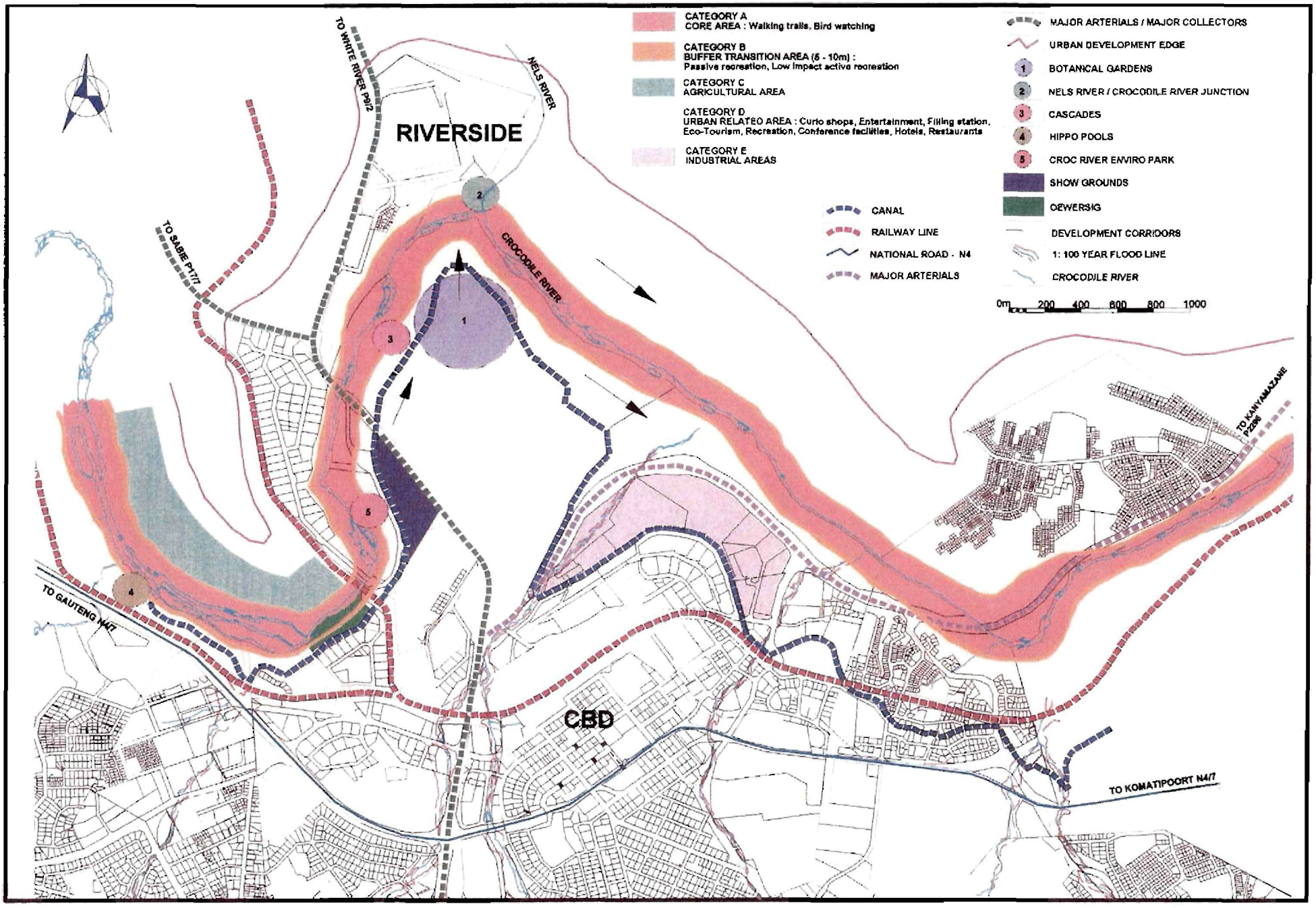


Figure 7.6: Different building categories of the Crocodile River Greenbelt Initiative Area (Anon, 2004).

7.5 Draft Open Space Bylaw.

Draft Bylaws were compiled by the MLM Parks Department under section 6(3) of the Mpumalanga Rationalisation of Local Government Affairs Act (10/1998), as well as section 156(2) of the Constitution of the Republic of South Africa Act (108/1996).

The Open Space Bylaw is applicable to all open spaces that fall under the jurisdiction of the council. The purpose of this bylaw is to control, manage and develop public open spaces in a way that is environmentally sustainable and is in the interest of the community of Mbombela.

The principles of the bylaw are that public open spaces must be managed and developed in the interest of the whole community, and environmentally sustainable and special measures must be taken to facilitate access by disabled persons. Recreational, educational and social opportunities of public open spaces must be protected and enhanced to improve and enrich the quality of life of the community. The natural environment and heritage resources within public open spaces must be identified, preserved, protected and promoted for the benefit of the local community, the public and future generations.

The Draft Open Space Bylaw (Anon, 2005) could include information on the unmanaged open spaces as well. With a detailed study of the unmanaged open spaces, the MLM would be able to identify sensitive areas and prevent development in these areas. It is important to incorporate the community in the protection of unmanaged open spaces such as drainage lines. Institutions like schools, churches and some societies could also be stakeholders in a project to manage and protect open spaces.

7.6 Environmental Impact Assessment (EIA) guideline for Mbombela

The aim of this policy is to ensure that all departments within the Mbombela Municipality will be able to comply with the principles and minimum standards for environmental management according to NEMA (107/1998). This policy complies with the requirements of relevant legislation as well as the Integrated Development Plan (IDP), 2002. The following two Directorates required guidelines for incorporated environmental procedures into their activities:

i. The Technical Directorate that included the Electrical, Civil Engineering, Urban & Rural development sub-directorate and Private Developers.
ii. The Community services Directorate that included the Health services, Community Services and Public Safety Services sub-directorate.

The EIA guideline was compiled in August 2002 and focused on the procedures of an EIA process for projects undertaken under the jurisdiction of the MLM. It referred to regulations of

1997 in terms of the Environmental Conservation Act (ECA) (73/1989). This document has to be amended to comply with the new EIA Regulations of April 2006.

7.7 Conclusion

Although this current study described the four biotopes as medium to high ecological value, urban areas were rated as low sensitivity according to the sensitivity maps of the SoER (2003) (Figure 7.1) and the Importance Rating of the EMF (2006) (Figure 7.3 and 7.4). The SoER (2003) have to be upgraded to include detailed studies of natural open spaces in urban areas. For monitoring of trends of degradation of the natural open spaces in urban areas, fixed monitoring points have to be identified. With the SoER, EMF and a well implemented SDF and LUMS, nature conservation can be improved and development planning in a city can aim to mitigate the impact of degradation forces (Hawkins & Selman, 2002). If urban ecological investigations in urban areas are not on the same scale as town planning, detection of actual dynamics and patterns will not be possible but may instead identify patterns that are artefacts of scale (Wiens, 1989; Rahbek, 2005).

The Crocodile River Greenbelt Policy is only applicable to a specific area along the Crocodile River in Nelspruit (Planning Area H). With the expansion of this document by the inclusion of the Sabie River in Hazyview, the North Sand River in Nkambeni and all wetlands and drainage lines in the whole Mbombela, the MLM would be able to control, monitor and manage these areas more effectively.

The EMF (2006) was compiled after this current study was started and research in specific areas, data collection by consultants for EIA studies and studies like the present one could improve future ecological ratings if it is done on a smaller scale. The rating of conservation value is discussed in Chapter 6.

CHAPTER 8



History and Spatial planning in Mbombela Local Municipality

CHAPTER 8
HISTORY AND SPATIAL PLANNING OF MBOMBELA LOCAL MUNICIPALITY

8.1 Introduction

The topography of Mbombela creates a wide range of ecological conditions and microclimates that support a high diversity of plant and animal species (Strategic Environmental Focus, 2006). Many natural open spaces in residential areas form part of corridors for animals. Land uses will influence the structure of vegetation (Nowak, 1991), the size of the parcels and the areas of natural and semi-natural vegetation (Mander & Jongman, 1998). Spatial planning is important in considering land use in order to maintain natural areas, as well as for the functioning of the ecosystem. Therefore, scientific urban ecology research and spatial planning could be useful for land management, nature conservation and pollution control (Niemelä, 1999). This study concentrated on sensitive natural open spaces in a rural residential area (Planning Area A – Hazyview) and an urban residential area (Planning Area H – Nelspruit) of Mbombela Local Municipality.

Nelspruit started as a small town with a population of 5500 in 1905 (Bornman, 1979) and merged during 2000 with White River and Hazyview (Transitional Local Councils - TLCs and Transitional Regional Councils – TRCs) as Mbombela Local Municipality (MLM) (Laduma., 2006). The size of Mbombela is 333071.72 ha with a population of 605 982 in 2004 and an estimated population of 785 333 in 2021 (Table 2.1), excluding the effect of HIV/Aids (Laduma, 2006). The Mbombela SDF (Laduma, 2006) estimates an average annual growth of 3.6% for 2004 -2009, 2.6% for 2009 – 2014 and 1.9% for 2014 – 2019. The average annual growth rate of 3.6% for 2004-2009 for Mbombela is higher than the National growth rate of 2% for South Africa (Statistics SA, 2000). Increased population growth has a high demand for residential areas and social services, which have a direct impact on the environment.

Hazyview originated as a trading post and holiday town on the farm De Rust which belonged to the famous game ranger, Harry Wolhuter (Bornman, 1995). The rural residential areas close to Hazyview are Tshabalala, Nyongani and Nkambeni and are part of the former KaNgwane Homeland. Nelspruit is the urban residential area and is named after the Nel brothers that used grasslands in the area for forage during 1870. The first permanent farmer recorded in Nelspruit was Mr. HL Halls (Bornman, 1979).

In this chapter the history of the two Planning Areas (A and H) and the demarcation of Mbombela will be discussed as well as the summaries of spatial planning policies that included the SDF (2006) and Draft LUMS (2006).

8.2 Demarcation of Mbombela Local Municipality (MLM)

Mbombela Local Municipality is divided in 9 subdivisions on a basis of different density categories. According to the SDF (Laduma, 2006), these divisions are based on the Development Facilitation Act (DFA) (67/1995) as well as other spatial planning principles where the core principle is that of population densities (Figure 8.1). The purpose of subdivision is to guide authorities in evaluations of applications for determining development conditions. According to the SDF (Laduma, 2006), these development conditions will have an impact on future land usage and ensure sustainable development (Figure 8.2).

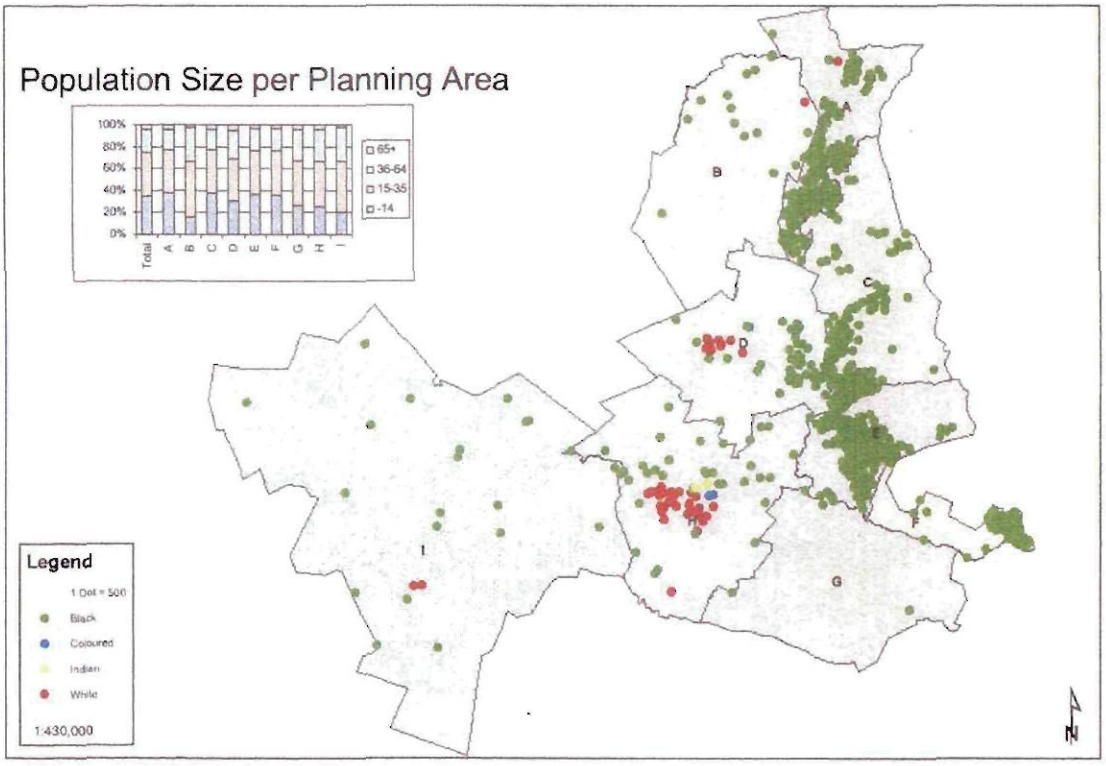


Figure 8.1: Demarcation of Mbombela's nine Planning Areas according to population densities (Naidoo *et al.*, 2003)

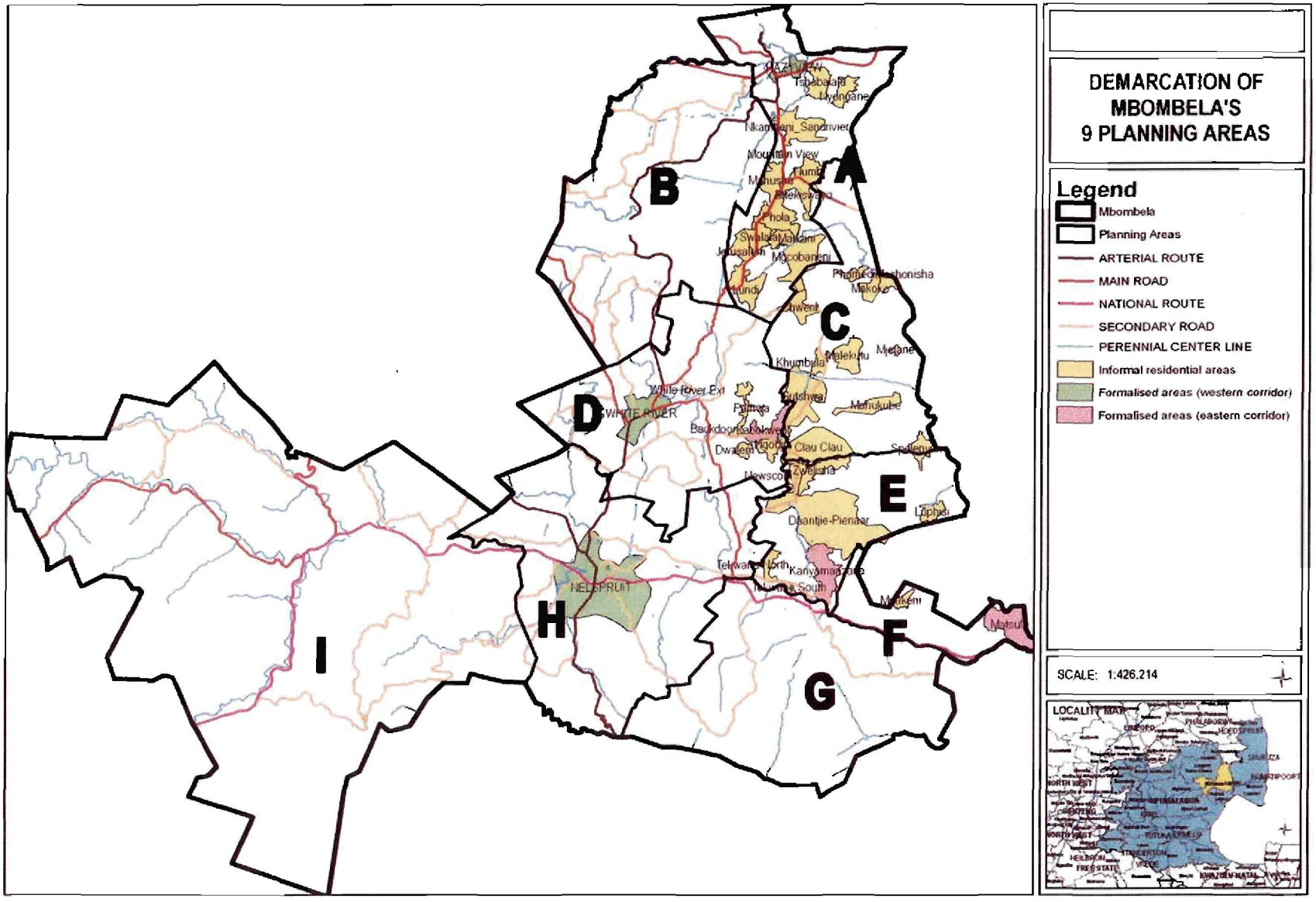


Figure 8.2: Demarcation of Mbombela's 9 Planning Areas

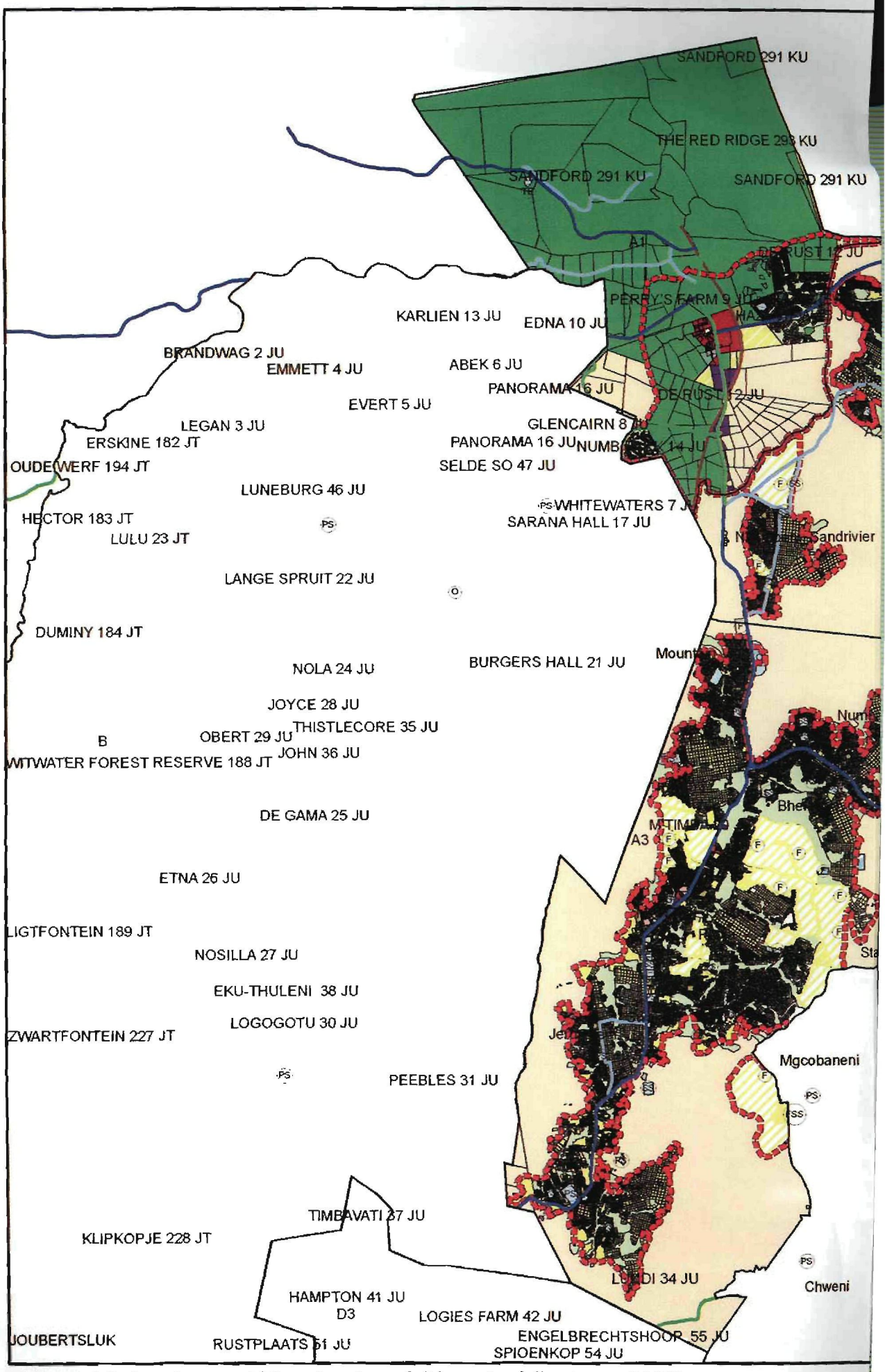
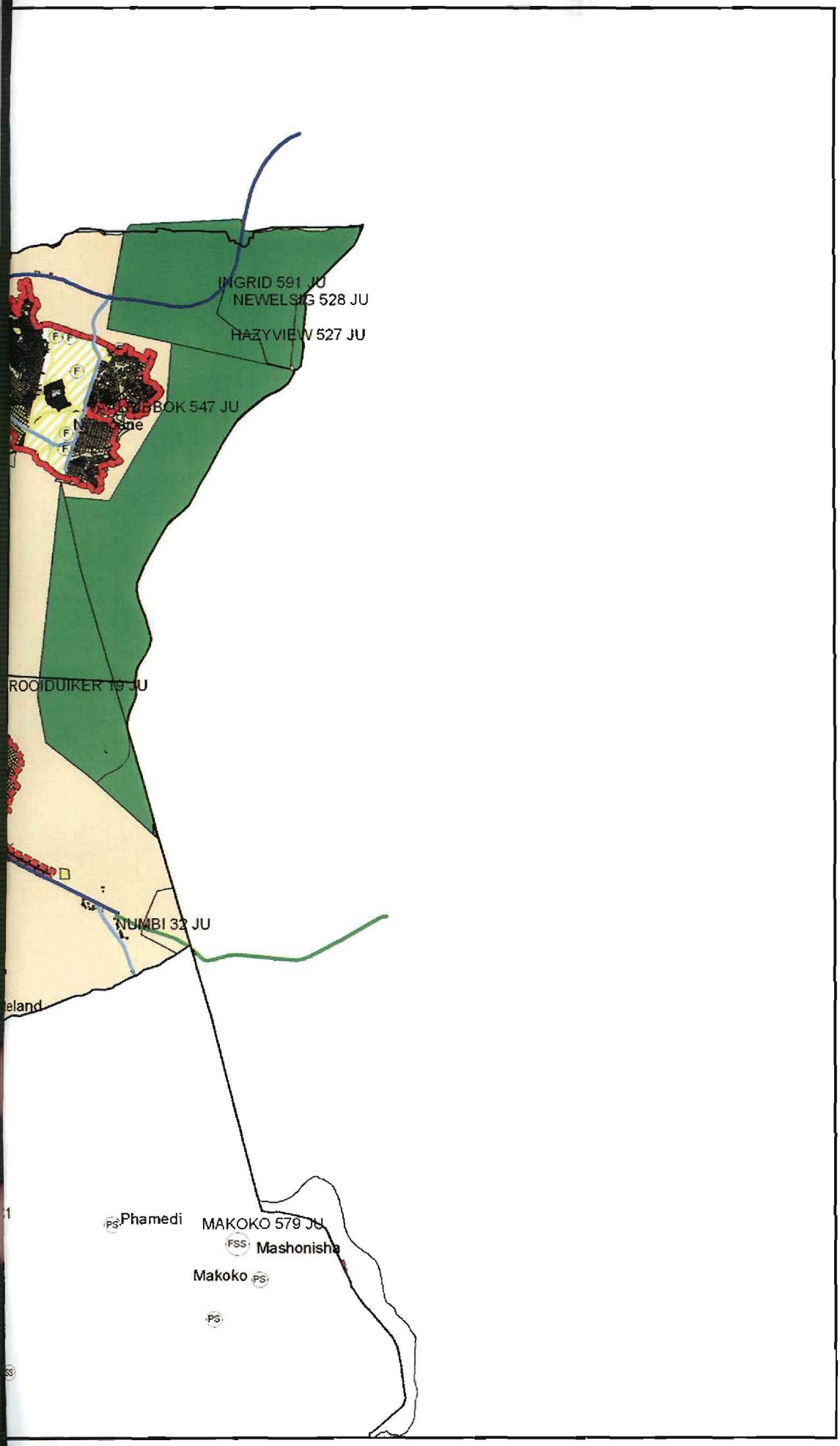


Figure 8.3: Land uses of Planning Area A (Hazyview) (Laduma, 2006)

P MSFR A



AllRoads12062006

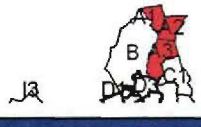
CLASSIFICATION

- Class U 1 National/Regional
- Class U 2 Primary Distributor
- Class U 3 Urban District Collector
- Class U 4 Urban Collector
- Class U 5 Local Streets
- Railway
- Water channel
- Urban Edge
- Agriculture
- Business
- Education
- Industria
- Conservation
- Tourism and Accommodation
- Open Space
- Residential
- Urban Agriculture
- Future Residential

N

1:120,000

Laduma Tapp
Tel: (013) 750 0360
Fax: (013) 757 1370
E mail: ladutapp@lafrica.com



MSFR A

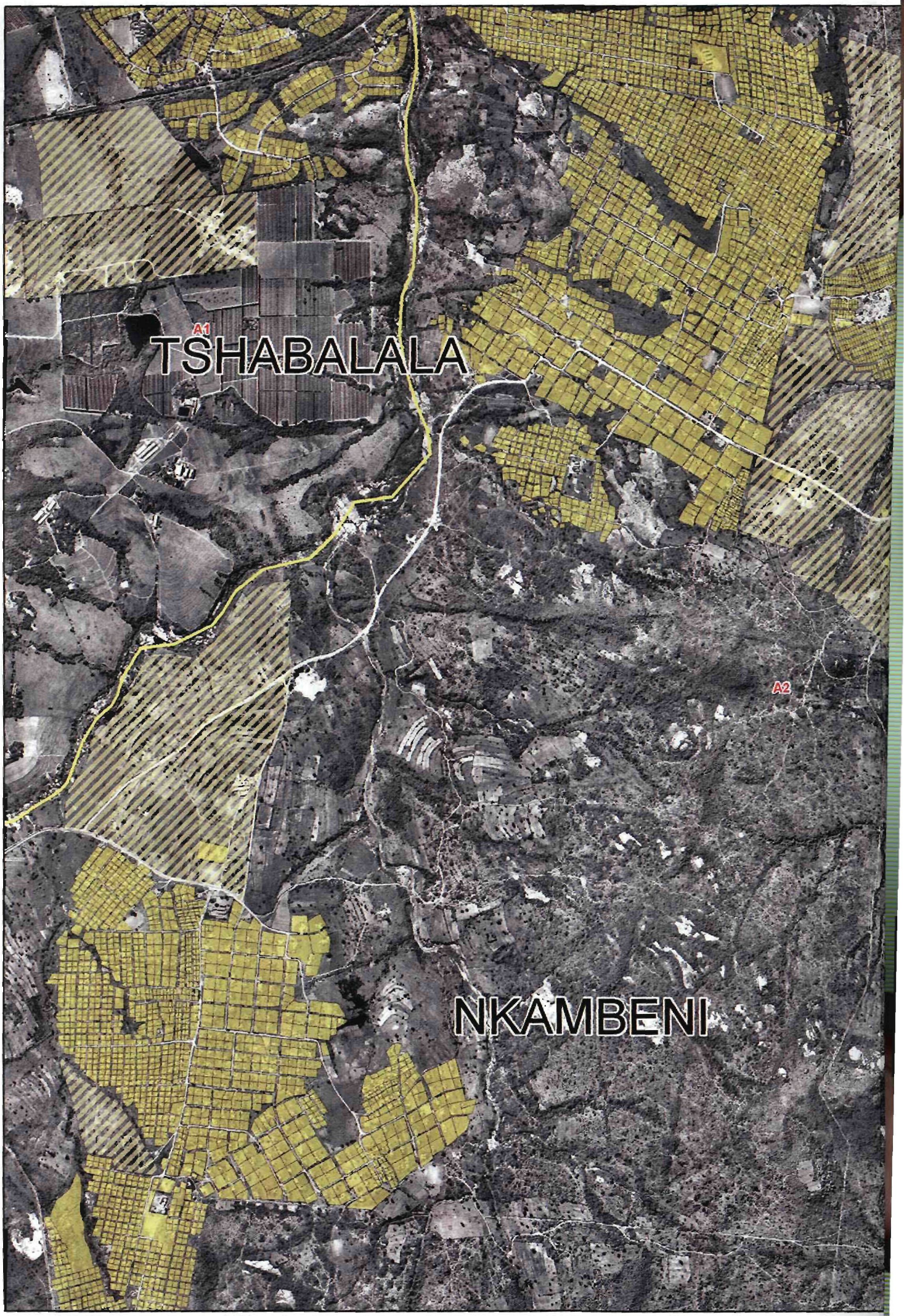
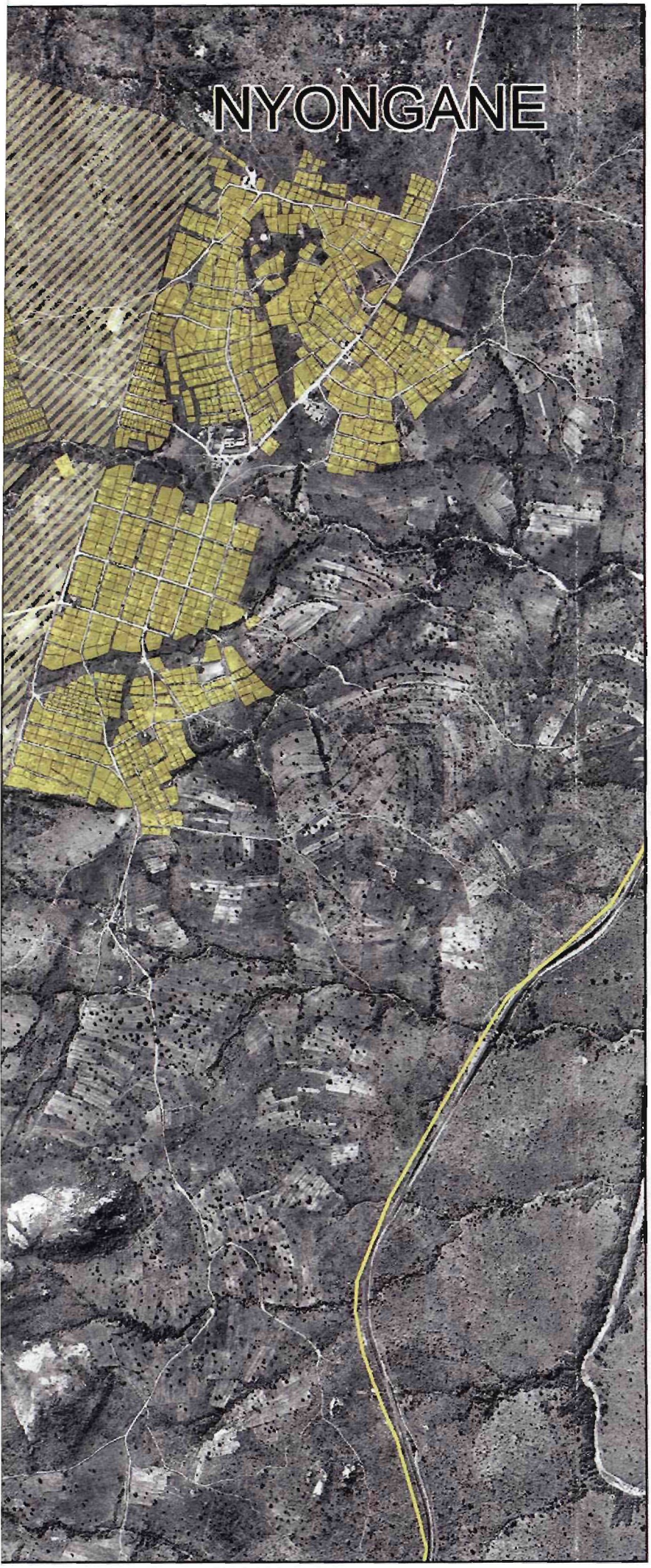


Figure 8.4: Aerial photo of Planning Area A: Residential areas and future development.

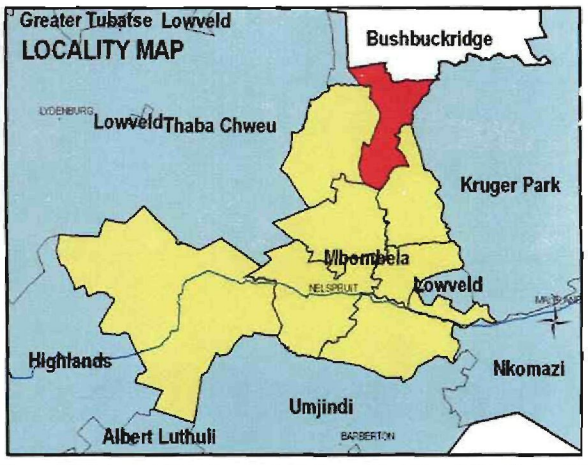


PLANNING AREA A
RESIDENTIAL AREAS

Legend

- Residenbal
- Future Residential

SCALE: 1:25,000



8.3 History

8.3.1 Development of Tshabalala, Nyongani and Nkambeni (Planning Area A2)

The name "Hazyview" originated from the misty view over the surrounding area with its many banana plantations. Hazyview was established in the early 1950s when it started as a trading post and fuel station for travellers because of the distance from White River, Sabie, the Kruger National Park and Phalaborwa. Hazyview was officially promulgated in 1959 when the first post office was established. Tshabalala, Nyongani and Nkambeni are communal lands ruled by Chief Mhaule of the Nkambeni Tribe. Tshabalala has officially planned residential areas while Nyongane's and Nkambeni's stands had been handed out by the chief. Most of the stands are rural villages supported by subsistence farming of crops and livestock on communal land (Figure 8.3 and 8.4).

8.3.2 Development of Nelspruit (Planning Area H)

Nelspruit started as a railway junction between Maputo and Pretoria. Development of the railway system started during 1884 and the official founding date of Nelspruit was 27th January 1905. A size of about 38 hectares was approved (Figure 8.5). During 1926/27 the Town Clerk planted trees along the streets of the town (Figure 8.6). Nelspruit had a population of 500 in 1915, which increased to more than a thousand in 1940. During 1951, the population increased to more than 2000, four times the initial number. The number of businesses increased from 261 in 1963 to 543 in 1973. During 1973 the population was 34 000.

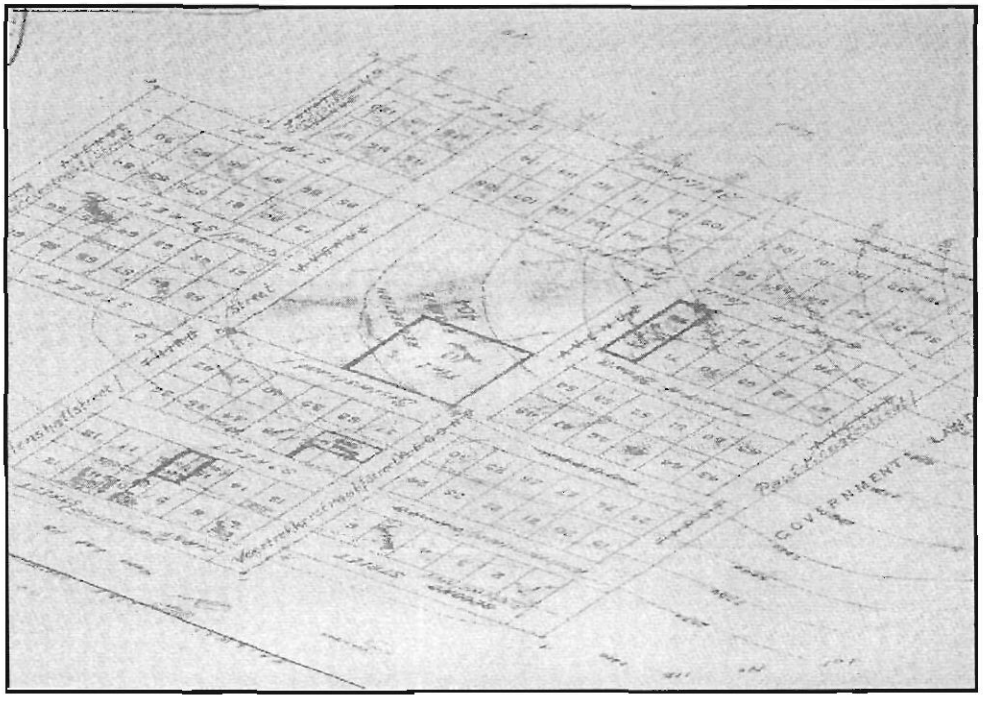


Figure 8.5: Street plan and layout of Nelspruit, 1904 (Bornman, 1979)

Planning Area H is a fast growing urban residential and industrial area with a high demand for houses and offices (Figure 8.7). The map with current land uses is presented in Figure 8.8 and an aerial photo of Planning Area H (Nelspruit) is presented in Figure 8.9.



Figure 8.6: Photograph of Nelspruit from the air in 1932 (Bornman, 1979)



Figure 8.7: A view of Nelspruit CBD and some residential areas on the hills (2007)

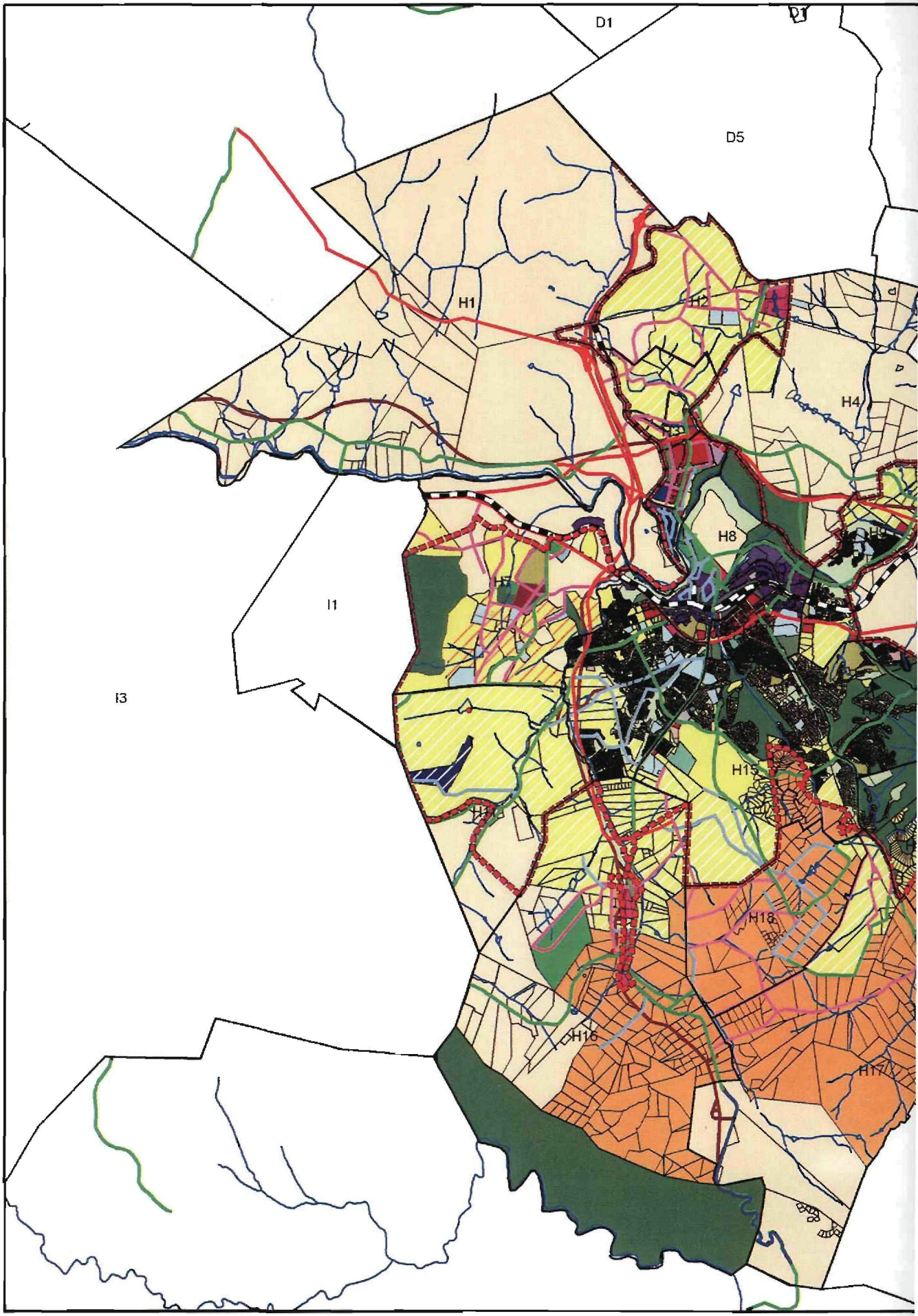
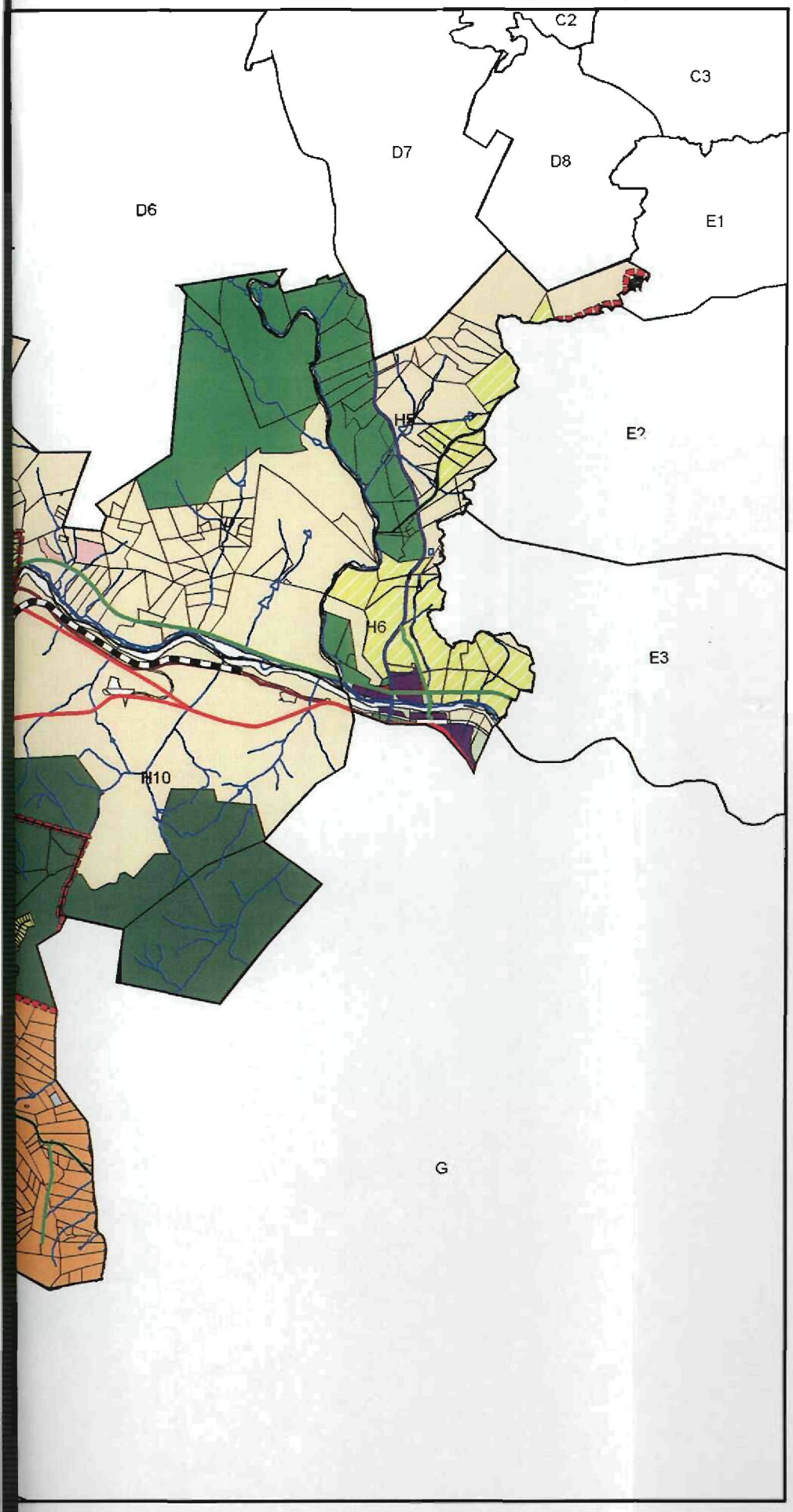


Figure 8.8: Land uses of Planning Area H (Nelspruit) (Laduma, 2006)

ISFR H



Legend

- Agriculture
- Airport
- Automotive
- Business
- Cemetry
- Commercial/Industrial
- Community Facilities
- Conservation
- Education
- Entertainment
- Future Education
- Future Industrial
- Future Residential
- Government
- Heavy Industrial
- Industrial
- Institutional
- Municipal
- Office
- Office/Residential
- Open Space
- Residential
- Rural Residential
- Service Industry
- Special
- Sport and Recreation
- Tourism and Accommodation
- Transport
- Urban Agriculture
- Utilities
- Rivers

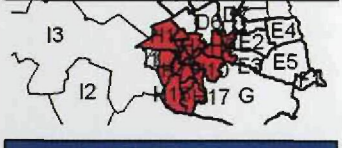
AllRoads12062006
CLASSIFICATION

- Class U 1: National/Regional
- Class U 2: Primary Distributor
- Class U 3: Urban District Collector
- Class U 4: Urban Collector
- Class U 5: Local Streets
- Railway
- Water channel
- Urban_Edge
- Interchanges

N

1:116,000

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MSFR H

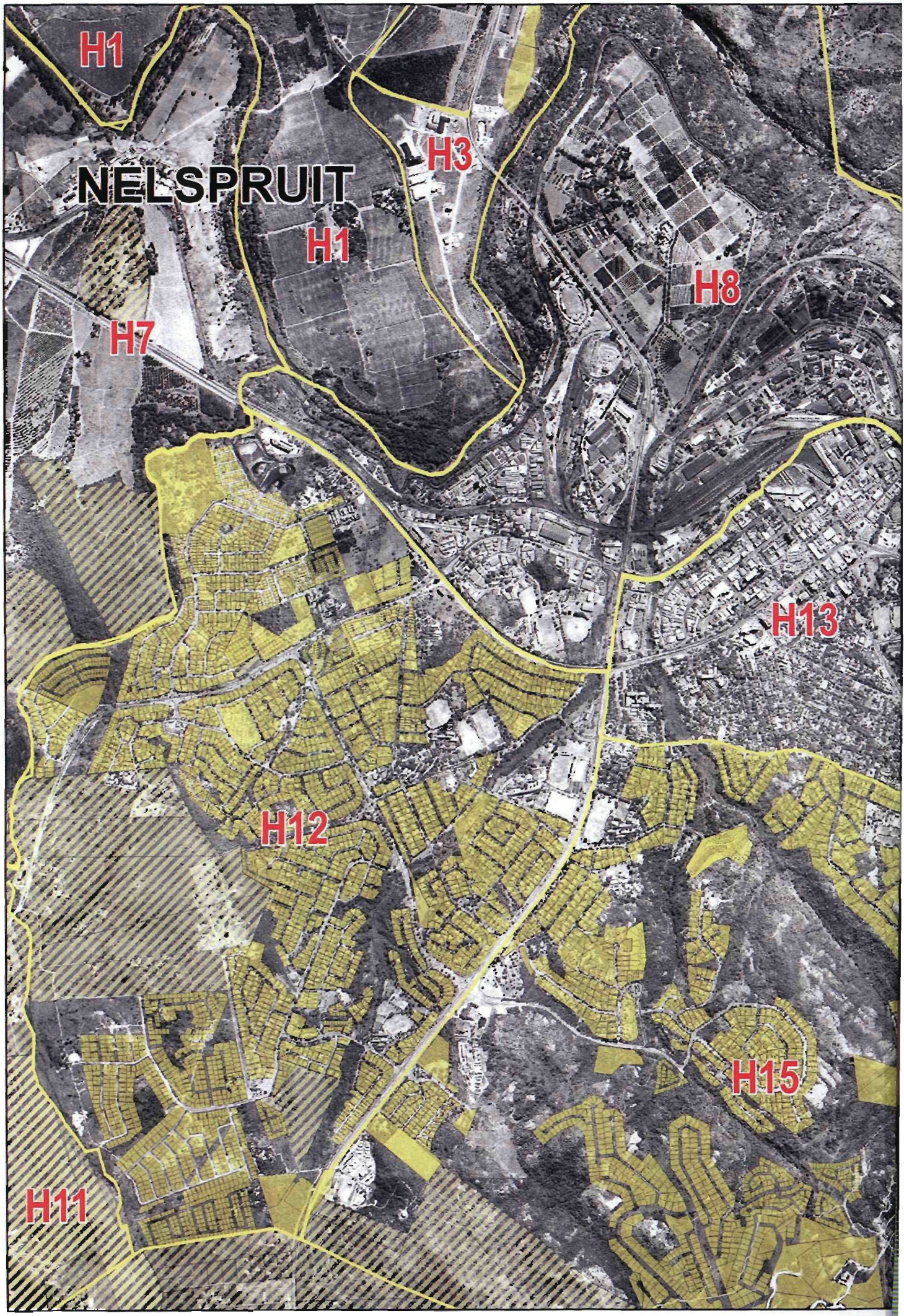
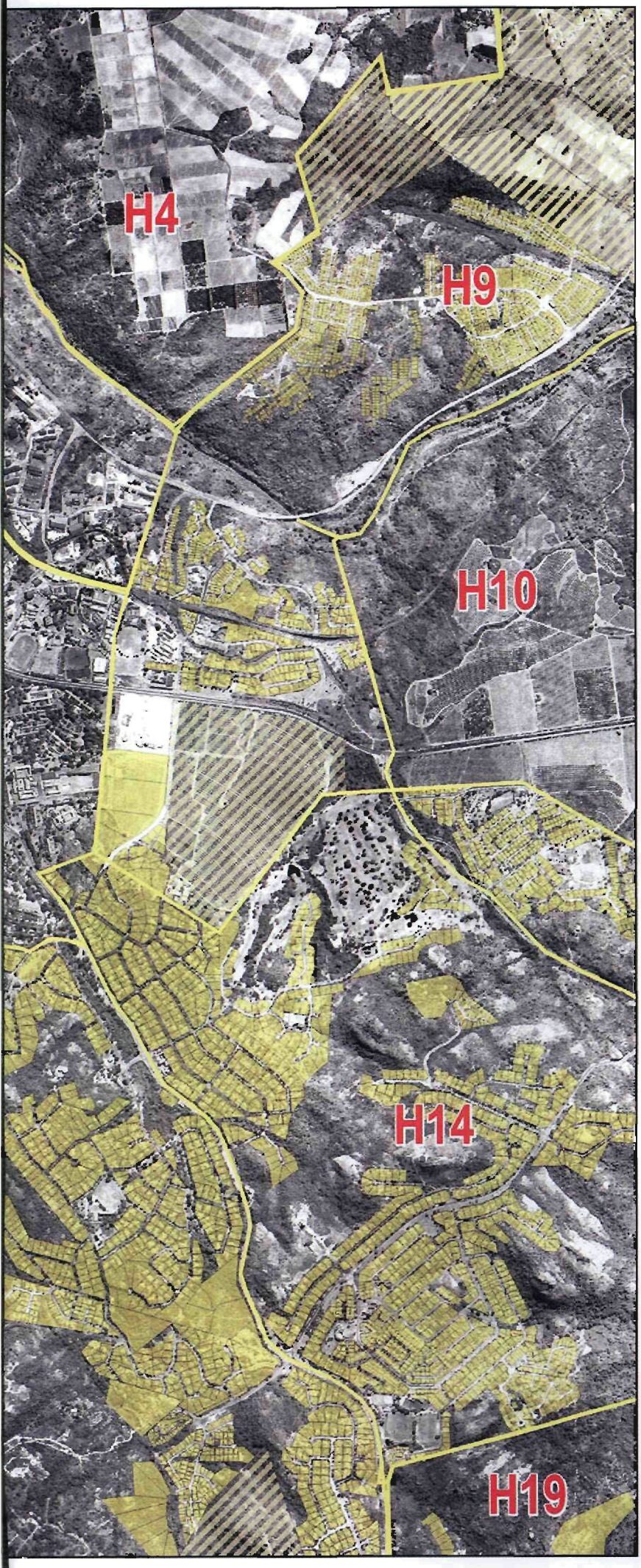


Figure 8.9: Aerial photo of Planning Area H: Residential areas and future development.



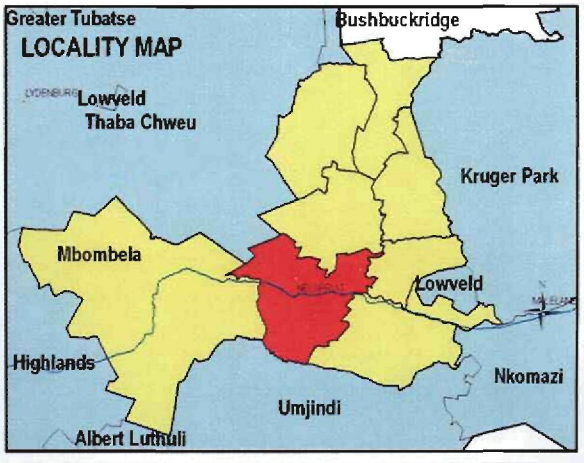
PLANNING AREA H
RESIDENTIAL AREAS

Legend

- Residential
- Future Residential

SCALE: 1:24,744

N



8.4 Spatial Planning Policy: Spatial Development Framework (SDF).

The Development Facilitation Act (67/1995) direct the land development must be sustainable, equal, efficient, integrated and based on fair and good governance. The principles are to achieve a better urban structure and involve the integration of physical, economic, social, institutional and environmental aspects which interrelate and interact with each other. The Land Use Management Bill (2001) determines that spatial planning and land use management have to complement the principles set out in the DFA (67/1995). Municipalities have to compile a SDF with the purpose to direct and control development.

The SDF provides information on where needs and priorities have developed and what strategies have to be adopted to ensure the integration of the different sectors. Strategic formulation requires responsible interventions which will have a short-term impact on existing development and simultaneously contribute to the long-term sustainability of development. The SDF of MLM has to be revised and refined on an annual basis because of the nature of the environment and the different levels of land use. The Mbombela SDF (2006) is part of the Mbombela IDP (2006/2007).

8.4.1 Spatial issues: Mbombela Local Municipality

The SDF (Laduma, 2006) provided development plans and development directives which consisted of two spheres of planning, Planning Areas and Planning Precincts. Mbombela is divided into 9 different Planning Areas to focus on development programmes and specific areas with a unique character as discussed earlier. Each Planning Area is divided into Planning Precincts to allow planning on a local level. The demarcation of these precincts is based on the role and function of each precinct as an entity as well as on physical factors such as roads, topography, rivers etc (Figure 8.2).

Mbombela's development pattern is the result of different factors such as segregation laws of the past, policies with regard to zoning, topographical factors, major routes, the railway lines, agriculture and forestry. This resulted in an urban and rural form that is grouped into different functional areas with different levels of development. Urban edges serve to compact the city by restricting growth within development corridors and nodes and to contain urban sprawl. Strategic development will be strengthened by densification through the provision of primary, secondary, community and tourism activity nodes as well as activity spines and streets. Optimal utilisation of all urban land uses will be facilitated by densification of residential and economic development nodes.

Information from the SoER (2003) was used to assess the existing environmental impacts of development. Environmental aspects that were assessed included topography and drainage

areas, sensitive habitats, conservation areas and sensitive biota. According to the SDF (Laduma, 2006), the impact of development on the environment was found to be as follows:

- The water sources within Mbombela are under pressure due to the high demand for human consumption.
- The loss and fragmentation of natural habitats are due to the agricultural and urban expansion.
- Land use activities have transformed most of Mbombela, where some remaining natural areas are conserved and others remain vulnerable and become "islands". Ecologically important "islands" include natural forests, wetlands, riparian zones and natural grasslands.
- Veld fires within Mbombela occur more often than the natural burning regimes and have an impact on vegetation structure and species composition.

The SDF (Laduma, 2006) quantified and qualified the effect that different land use types have on the natural habitat. The conservation of the environment includes the identification of biologically sensitive areas and the integration thereof into the SDF, which provides the basis for future spatial development. According to the SDF (Laduma, 2006) most important conservation resource is management in relation to the green space, where the SDF (2006) protect, enhance, utilise and rehabilitate the remaining natural resources.

8.4.2 Spatial issues: Planning Area A (Hazyview)

Planning Area A is known as Hazyview Area and has three Planning Precincts (A1, A2 and A3) (Figure 8.3). Planning Precinct A1 consists of Hazyview Urban Areas and surrounding settlements, A2 consists of the settlements of Nyongani, Tshabalala and Nkambeni (Figure 8.10) and A3 consists of the settlements of Numbi, Mashushu, Salubindza, Bhekiswayo, Phola, Swalala, Mzni, Jerusalem, Legogote and Lundi.

The estimated population growth for the next five years is 24272 persons (Table 2.1). When planning for 6 persons per household, 4049 houses will be needed within the next 15 years. With no suitable engineering infrastructure, water networks or sewerage systems, planning of residential areas has to be planned carefully not to harm the environment and to obey the different legislations for urban development. The area needs to be regenerated to allow for sustainable rural settlements with a supportive social and engineering infrastructure.

Planning Area A2 has limited growth. A housing project on the land between Nyongani and Tshabalala will add 1000 families to the precinct (Figure 8.3). The area has a limited economic base. Enterprises which focus on retail, services and small workshops and social facilities such as clinics, schools, post offices, community halls etc. are dispersed through the area which resulted in an unplanned structure.

The engineering infrastructure does not provide for sustainable development. The water network forms part of the Northern Nsikazi water supply system feeding from the Sabie River. The availability of water in the area is severely affected by the disruptions of the network, which include illegal connection, water losses and wastage and the restricted bulk water supply. This causes uncertainty about new development in the area. A Water Services Management Plan needs to be prepared in order to ensure the integration of existing and new developments with the provision of water services.

The sampling points of this current study, as discussed in Chapter 3, concentrated in Planning Precinct A2 (Figure 3.3), and further discussions will be only of Planning Precinct A2. The development directives are discussed under Critical Development Issues, Developing Strategies and Developing Directives.

8.4.2.1 Critical development issues for Planning Precinct A2 (Laduma, 2006):

The Nyongani/Tshabalala/Nkambeni Precinct is a rural development precinct with rural practices such as livestock farming and low-density residential settlements which resulted in an unplanned structure. The availability of water is affected by disruption of the network and restricted bulk water supply. A Water Service Management Plan needs to be prepared.

8.4.2.2 Development strategies for Planning Precinct A2 (Laduma, 2006)

The area needs to be regenerated to allow for sustainable rural settlements with a supportive social and engineering infrastructure. Development strategies for the precinct are:

- The clustering of retail and social facilities
- To discourage the uncontrolled invasion of residential development
- The provision of tourism facilities
- The provision of informal as well as formal economic activities needs to be considered. The spaza shops, tuck shops, personal services, taverns and workshops within residential areas. These land uses need to be provided as consent uses rather than as permanent primary uses.

8.4.2.3 Development directives for Planning Precinct A2 (Laduma, 2006):

The development directives for Residential and Business use as well as for open spaces are:

Residential use

- Residential development should be sustainable.
- The protection of open spaces should be a priority and areas within 1:100 year flood line needs to be cleared from development.
- New development should provide for smaller erven (14 stands per gross ha) with a

minimum erven size of 500m^2.

- Non-residential facilities should be provided with the conditional consent of the municipality after the neighbours have been consulted. Scrap yards and workshops should be phased out and established in demarcated areas.

Business use

Provision of formal and informal land uses needs to be considered.

Open spaces

Open spaces need to be functional and should developments fronting into parks be sensitive to the character and functioning of the park. Open spaces can be used for agricultural purposes.

Conservation use

- The eastern parts of the area adjoining the boundary of the Kruger National Park need to be regarded as a transient zone. A Development Plan needs to be prepared.

Agricultural use

Developments within the Agricultural zone should adhere to the following development guidelines:

- The land uses should be restricted to agricultural and tourism activities and uses ancillary and complementary thereto.
- If business or activities of another nature is provided within the zone, it can only be allowed as a temporary use for a period of 5 years.
- An Environmental Management Plan should be provided with every new development or changes in land use.
- A site development plan involving the design and functional utilisation of the site must be approved by the municipality.
- Subdivision of farm portions will be allowed provided that the consent of the National Department of Agriculture had first been obtained
- Sand mining needs to take place with the necessary consent of the Department of Minerals and Energy.

Rivers, natural forests and wetlands

These areas should be protected against any development affecting these areas.

MAP MSFR A2

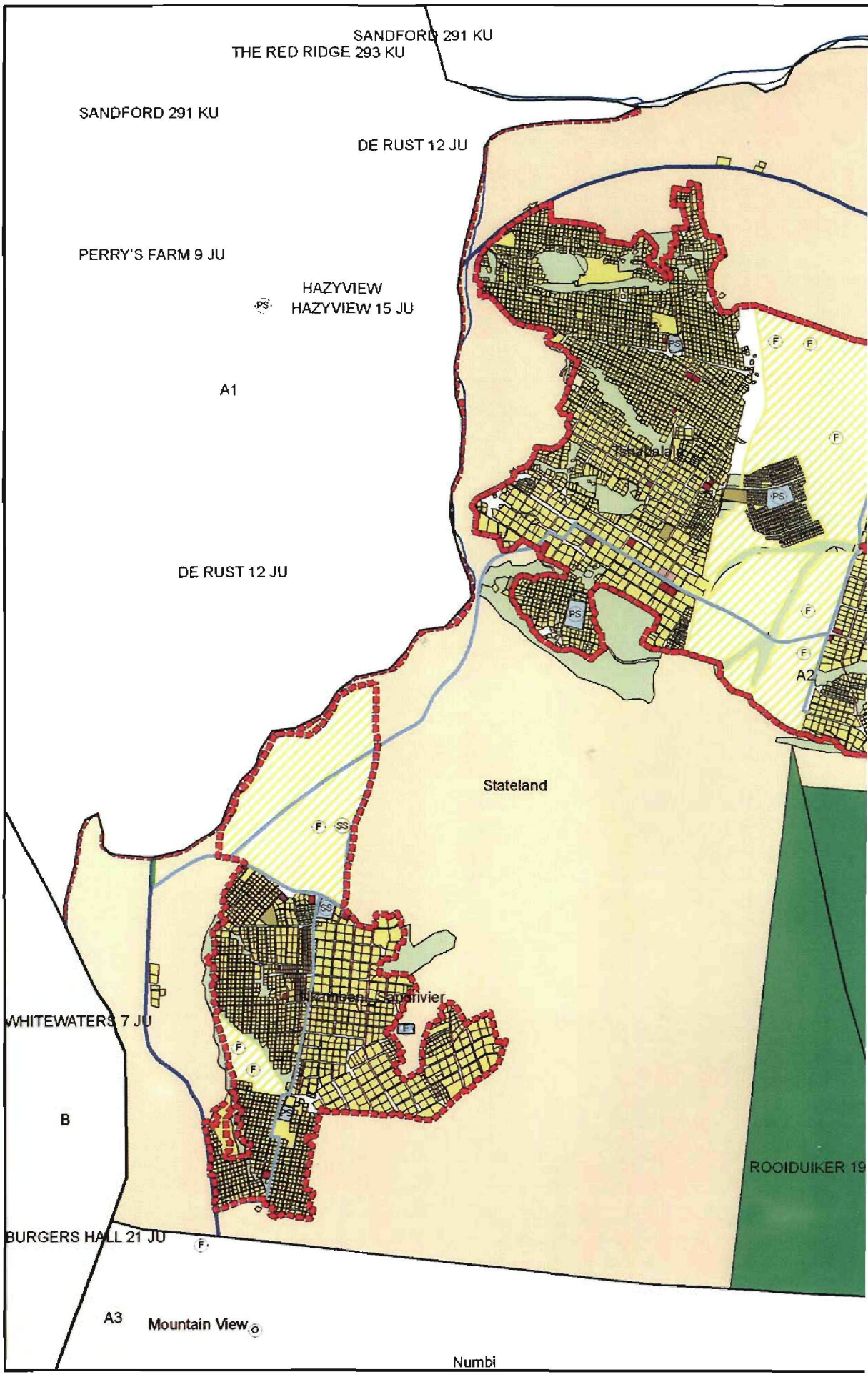
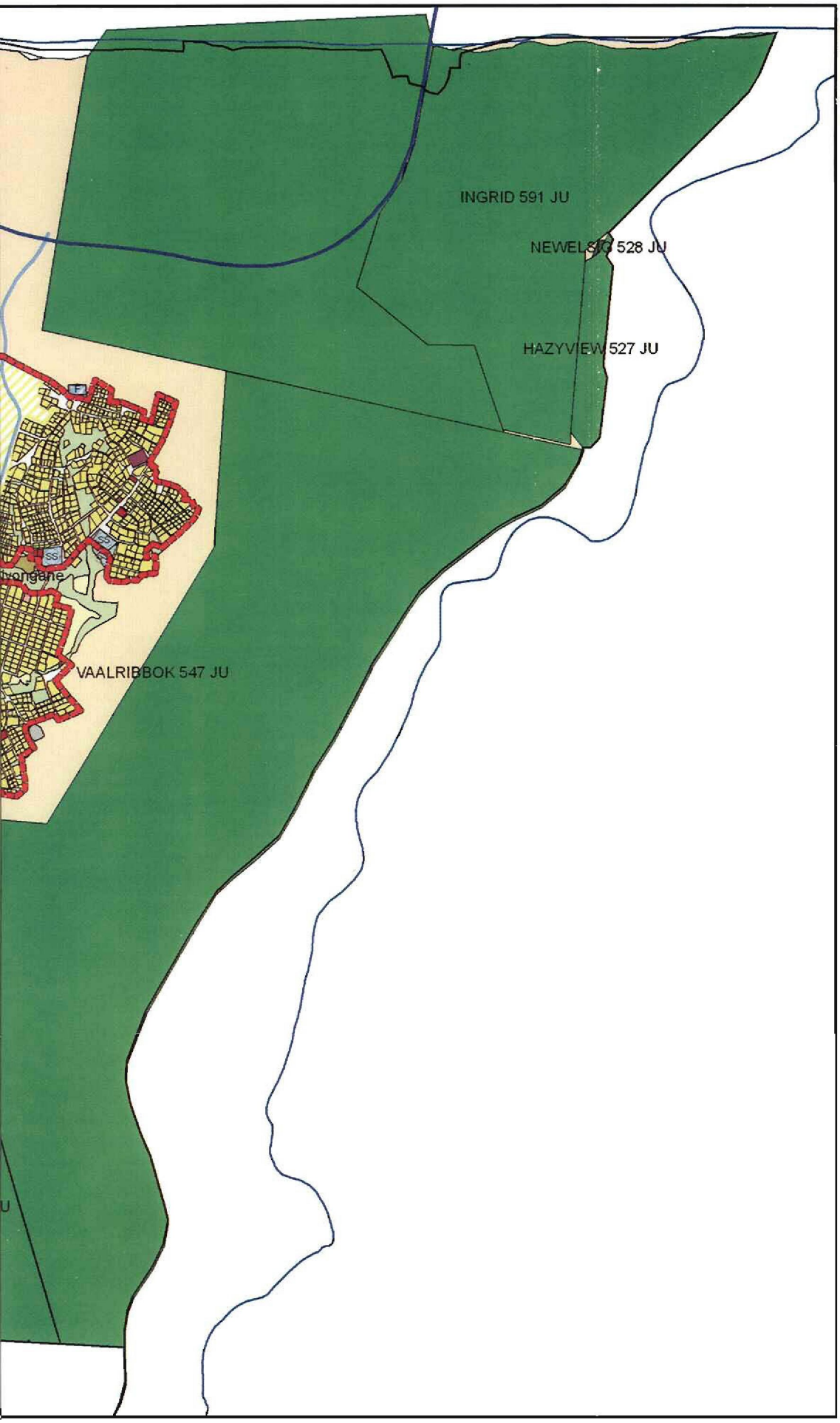


Figure 8.10: Planning Precinct A2 land uses (Laduma, 2006)

Nyongani/Tshabalala/Nkambeni



Agriculture
Entertainment
Business
Community Facilities
Cemetry
Education
Urban Agriculture
Residential
Future Residential
Conservation
Tourism and Accommodation
Open Space
Sport and Recreation
RMoF_Farms
Rivers

AllRoads12062006

CLASSIFICATION

Class U 1: National/Regional
Class U 2: Primary
Class U 3: Urban
Class U 4: Urban Collector
Class U 5: Local Streets
Railway
Water channel
Urban_Edge
Interchanges

N

1:42,000

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MSFR A2

8.4.3 Spatial issues: Planning Area H (Nelspruit)

Nelspruit is the regional commercial, industrial, administrative and service centre for Ehlanzeni District, Mpumalanga. Existing economic thrusts have to be utilized to stimulate and integrate socio-economic development and growth in the whole of the Mbombela area.

Table 2.2 estimated a population growth of 134 367 in Planning Area H for the next fifteen years. With average of six persons per household, 22395 houses have to be built within the next 15 years. With the many industrial activities, sensitive environment and high demand for residential housing in Planning Area H, good planning is needed not to harm the environment.

The SDF provides the conceptual spatial aspects of the location of needs and priorities, and the strategies that must be adopted to ensure an efficient and integrated urban system of physical, economic, institutional and environmental factors. The strategic SDF includes detailed planning, focusing on identified nodes / development precincts demarcated according to the role and function of each precinct, as well as physical considerations such as topography, roads and rivers. It takes the interdependence of the rural and urban components into consideration.

Strategic development will be strengthened by densification through the provision of primary, secondary, community and tourism activity nodes as well as activity spines and streets. Intensification and optimal utilisation of all urban land uses will be facilitated by densification of residential and economic development nodes. The former will be conducted in a manner that is sensitive to maintaining quality of life for residents, for instance, by the provision of social and engineering infrastructures.

Rural areas are to be developed according to the compatibility of the specific land use and should consist of functional corridors and zones, such as agriculture zones e.g. irrigation farming, low density residential areas, game farming, etc. Areas of a residential nature will be densified and upgraded with regional services for instance cemeteries, reservoirs, etc as well as other uses such as mining and quarrying. Rural residential development for planning purposes is regarded as areas where densification is most unlikely to happen. Provision of land for rural development must make allowances for all forms of farming activities required as well as consider the protection of the environment.

Development will be sustained by encouraging manufacturing industries along the Maputo Development corridor, such as providing retail and office facilities and developing ancillary and complementary functions such as an Industrial Development Zone (IDZ) to the Kruger Mpumalanga International Airport. Tourist- and motorist-related activities could be encouraged along the N4, developing speciality zones such as heritage and conservation sites and

protecting prime agricultural land. Housing must be concentrated in existing development nodes and corridors. It must provide for the entire spectrum of income groups, allow for social and economic infrastructure and take into consideration the availability of water resources and impacts on environmental sustainability.

The strategy for environmental conservation includes restricting development in biologically sensitive areas and controlling growth so as to promote environmental conservation, the conservation and productive utilisation of high quality agricultural land, the identification and application of a structured green web, which includes areas that need to be conserved, created or rehabilitated and the provision of interfaces to protect areas from urban creep. The biosphere concept will be applied, which involves the identification and implementation of core conservation, buffer and transition areas (Figure 8.8).

Planning Area H (Nelspruit) has 19 Planning precincts (Figure 8.8) and this current study concentrated on sensitive natural open spaces within residential and industrial areas. Sampling points were chosen in Planning Precincts H3, H7, H8, H12, H13, H14 and H15 (Figure 3.5). Further discussions concentrate on these planning precincts under critical development issues, development strategies and development directives.

8.4.4 Precinct H3 – Riverside Park Development node:

8.4.4.1 Critical development issues of Planning Precinct H3 (Laduma, 2006):

Since its conceptualisation in 1994, the Riverside Park Development Precinct has developed into a significant regional business node, providing for a variety of business functions. The precinct is a strong motor related district consolidating the existing motor trade sector in a concentrated area. It consists of:

- The development of the Riverside Industrial Park.
- The Riverside Node was established for car dealerships.
- The Riverside Phase I has sufficient bulk infrastructure to allow for the development of the existing rights. The development of Phase 2 of the precinct will require the development of new and the upgrading of existing engineering infrastructure. The Botanical Garden (dark green) and the Greenbelt area (light green) are part of Planning Precinct H3 (Figure 8.11). The Crocodile River and Nels River trail through this Planning Precinct. The Nels River and Crocodile River meet in the Botanical Garden and have scenic value. Several wetlands are also part of this Planning Precinct.

8.4.4.2 Development Strategies of Planning Precinct H3 (Laduma, 2006):

The existing regional activities will be complemented by the following functions provided west of the R40:

- A Commercial and Industrial Business zone
- A Business zone
- A Residential zone providing for a variety of residential densities, including low, medium and high density residential uses
- The distribution of commercial and business activities within the node should take place in a flexible manner to assure the optimum utilization of exposure and establishment preferences in accordance with an approved Precinct Development Plan.
- The Crocodile River should be regarded as a tourist recreation attraction and the utilisation thereof should take place in terms of an environmental management plan.
- All engineering services must be provided by the developers in agreement with the Mbombela Municipality.

8.4.4.3 Development Directives of Planning Precinct H3 (Laduma, 2006):

Business Use

- Business / Commercial zone should provide for a variety of business uses including retail, hotels, restaurants, offices, vehicle sales and related uses as well as educational facilities
- Commercial/ Industrial Use
- The Commercial / Industrial use should provide for a variety of business uses including retail, hotels, restaurants, offices, vehicle sales and related uses as well as educational facilities
- The development controls on all stands must be to the satisfaction of the Mbombela Municipality.

Residential Use

- Residential uses include low-, medium- and high density residential uses.
- The development controls on all stands must be to the satisfaction of the Mbombela Municipality.

Figure 8.11: Planning Precinct H3: Riverside Development Node land uses (Laduma, 2006)

8.4.5 Precinct H7: Sport Precinct

8.4.5.1 Critical Development Issues of Planning Precinct H7 (Laduma, 2006)

This precinct consists of the following existing dispersed developments that are to be integrated into an urban framework providing for the Soccer 2010 Sport Stadium (Figure 8.12). The Gateway development district consists of:

- Halls Gateway tourism business centre
- The Mpumalanga Parks Board offices
- TRAC offices
- Hall's offices and residential area
- The Mataffin Villages
- Informal Developments
- Intensive Agriculture
- Extensive agriculture and open spaces

8.4.5.2 Development Strategies for Planning Precinct H7 (Laduma, 2006):

The proposed development should create a socio-economic activity node with considerable future development potential, providing for:

- A stadium providing for the Soccer 2010 World Cup finals
- Future residential development, with associated supportive business and commercial development
- A business/tourism node
- An arterial linkage between the Sport (Mataffin) Precinct and the Riverside development node to improve regional and sub regional accessibility
- The responsible management and protection of sensitive natural environments

8.4.5.3 Development Directives for Planning Precinct H7 (Laduma, 2006):

Conservation

A Development Plan needs to be prepared involving the following actions in order to ensure the integration of the surrounding land uses:

- Assessment of Existing Environmental Factors
- Assessment of Development Potential
- Preparation of detailed development directives.

Sport and Recreation

The FIFA guidelines on stadium planning need to be imposed

Future Residential Use

- Second dwellings can be allowed on all residential stands
- Guest houses and tourist-related facilities will be allowed, subject to a compatibility analysis of the land uses with the consent of the municipality.

Mixed Land Use

- Mixed land uses need to be compatible in terms of environmental impact. The following elements need to be addressed with the assessment of proposals:
- Detailed planning and policy formulation, viability assessment
- An indication of where and how intensification could be allowed
- Restricting the intrusion of noxious and nuisance-creating activities into residential areas
- The reasonable rights of existing neighbours
- Performance based criteria should be applied as opposed to user based criteria.
- Future Residential Zones in terms of the mixed land use destination should encourage the following guidelines:
- A gross density of 20 units per hectare will be allowed.
- Second dwellings can be allowed on all residential erven.
- Guest houses and tourist-related facilities will be allowed, subject to a compatibility analysis of the land uses with the consent of the municipality.

Agricultural Use

- Developments within the Agricultural zone should adhere to the following development guidelines:
- The land uses should be restricted to agricultural and tourism activities and uses ancillary and complementary thereto.
- If businesses or activities of another nature are provided within the zone, it can only be allowed as a temporary use for a period of 5 years.
- An environmental management plan, headed by an Environmental Impact Assessment, which includes control measures and development directives, should be provided with every new development or change in land use.
- A site development plan involving the design and functional utilisation of the site should be approved by the municipality.
- Subdivision of farm portions will be allowed subject to a subdivision policy of the

municipality, provided that the consent of the National Department of Agriculture has first been obtained.

- Sand mining has to take place with the necessary consent of the Department of Minerals and Energy.

Tourism and Accommodation Use

- The tourism development zone should adhere to the following development guidelines:
- The land uses should be restricted to agricultural and tourism activities and uses ancillary and complementary thereto.
- An environmental management plan, headed by an Environmental Impact Assessment, which includes control measures and development directives, should be provided with every new development or change in land use.
- A site development plan involving the design and functional utilisation of the site should be approved by the municipality.

Rivers, natural forests and wetlands

These areas should be protected against any development affecting these areas. Development should only be allowed after formal procedures as specified in environmental legislation have been conformed with.

Figure 8.12: Planning Precinct H7: Sport Zone (Laduma, 2006)

8.4.6 Precinct H8: Nelspruit Industrial/Commercial/Nelspruit Crocodile River Greenbelt Areas

8.4.6.1 Critical development Issues for Precinct H8 (Laduma, 2006)

Most of the stands within these areas are already developed. Further development within the Nelspruit Industrial/Commercial Areas can mainly take place through a process of densification. The Nelspruit Showground, Croc River Enviro Centre, and the Lowveld Botanical Gardens and surrounding underutilized land provide the opportunity of creating a tourism node as part of the Crocodile River Open Space System. Accessibility to this area needs to be enhanced (Figure 8.13).

8.4.6.2 Development Strategies for Precinct H8 (Laduma, 2006):

Industrial/Commercial

Development of the Nelspruit and Riverside Industrial/Commercial areas should take place within a framework of densification within the existing areas.

Heavy Industrial

Further extensions to the heavy industrial areas must not be encouraged due to the incompatibility thereof with the objective to develop the Mbombela area for tourism.

Tourism

A tourism node including the Lowveld Showground, the Croc River Enviro Park and the surrounding vacant and underutilized land parcels needs to be provided as part of the Nelspruit Greenbelt Zone. Direct access to the R40 Route needs to be provided in order to enhance the regional and sub-regional status of the area as a tourism node.

Agriculture

The ARC agriculture research centre will remain on the site in the long term.

8.4.6.3 Development Directives for Precinct H8 (Laduma, 2006):

Industrial/Commercial Use

- The development of industrial stands must not be restricted and allowed to develop to its full potential.
- Where industrial areas front onto open spaces, the owners/developers of properties must be encouraged with the approval of the site development plan and building plans:
- To provide a landscaped buffer (5m) on the boundary facing the open space
- To attend to the elevation treatment of buildings facing the park

Heavy Industrial Use

Noxious industries may be allowed in heavy industrial areas if all the relevant environmental legislation is being adhered to. Heavy industrial uses should be restricted to the existing demarcated areas.

Agricultural Use

The land can be used for research and educational purposes.

Tourism and Accommodation Use

- The tourism development zone should adhere to the following development guidelines:
- The land uses should be restricted to tourism activities and uses ancillary and complementary thereto. A site development plan for the design and functional utilisation of the site has to be approved by the municipality.

Conservation Use

A Development Plan needs to be prepared involving the following actions in order to ensure the integration of the surrounding land uses:

- Assessment of Existing Environmental Factors
- Assessment of Development Potential
- Definition of the Project Concept
- Preparation of a Land Use Plan and development directives.
- Preparation of Business Plans

Figure 8.13: Planning Precinct H8: Nelspruit Industrial and Commercial Areas (Laduma, 2006)

8.4.7 Precinct H12 – West Acres

8.4.7.1 Critical Development Issues for Precinct H12 (Laduma, 2006):

This precinct is the West Acres Residential area (Figure 8.14).

8.4.7.2 Development Strategies for Precinct H12 (Laduma, 2006):

The residential areas need to be protected against intrusion of non-compatible uses. Densification of the residential precincts should provide for a combination of:

- Smaller average erven sizes through the subdivision of single residential stands
- Medium density houses in residential areas including duets, townhouses and group houses
- Higher density multiple storey houses in development nodes
- Second dwelling units

8.4.7.3 Development Directives for Planning Precinct H12 (Laduma, 2006):

Residential use

- The maximum residential densities are applicable to the residential areas.
- Open spaces need to have a well-connected network and should developments fronting onto parks be sensitive to the character and functioning of the park and in accordance with the open spaces guidelines.

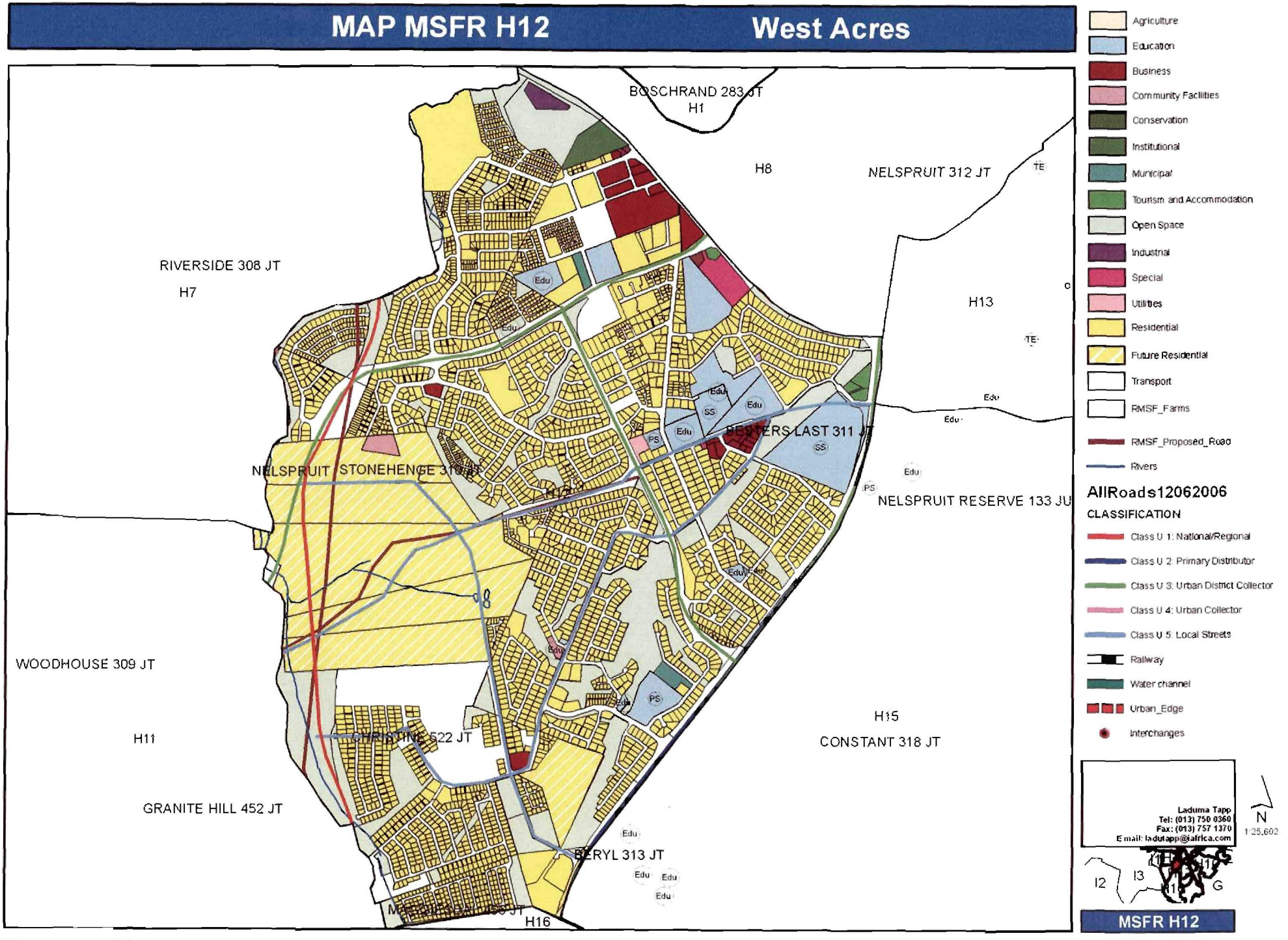


Figure 8.14: Planning Precinct H12: West Acres Residential Area (Laduma, 2006)

8.4.8 Precinct H13 - Nelspruit Central Business District (CBD)

8.4.8.1 Critical Development Issues for Precinct H13 (Laduma, 2006):

The N4 route passes through the Nelspruit CBD (Figure 8.15), resulting in the movement of national and regional traffic. A bypass for heavy vehicles around Nelspruit without compromising the regional and local accessibility of the Precinct needs to be provided. The following trends, which may have an impact on the retail development within the Nelspruit CBD, are experienced within Mbombela:

- The take-up rate of erven within the extended office zone is rapidly increasing.
- Limited housing is provided within the CBD, restricting integration of place of living with place of work.
- The future development and growth of the area will require positive public as well as private intervention in order to create sustainable investment and business confidence within the area. These interventions require proper planning, direction and application of funding, capital, infrastructure as well as natural resources on a local as well as regional level. This requires the institution of a proper local institutional development framework, which will provide the optimal interaction between government, the private sector and the community.

8.4.8.2 Development Strategies for Precinct H13 (Laduma, 2006):

Development of the Nelspruit CBD needs to take place by prohibiting further extension to the CBD and to accommodate commercial/retail, office, tourism and residential growth and redevelopment within its existing boundaries.

8.4.8.3 Development Directives for Precinct H13 (Laduma, 2006):

- High-density housing needs to be provided within the CBD.
- New developments in the Office/Residential node must be made subject to:
- The site development plans for offices and residential buildings should attend to the privacy of residential buildings.
- A maximum height of two (2) storeys should be allowed.
- At least 15% of the area of the erven should be landscaped to the satisfaction of the Council.

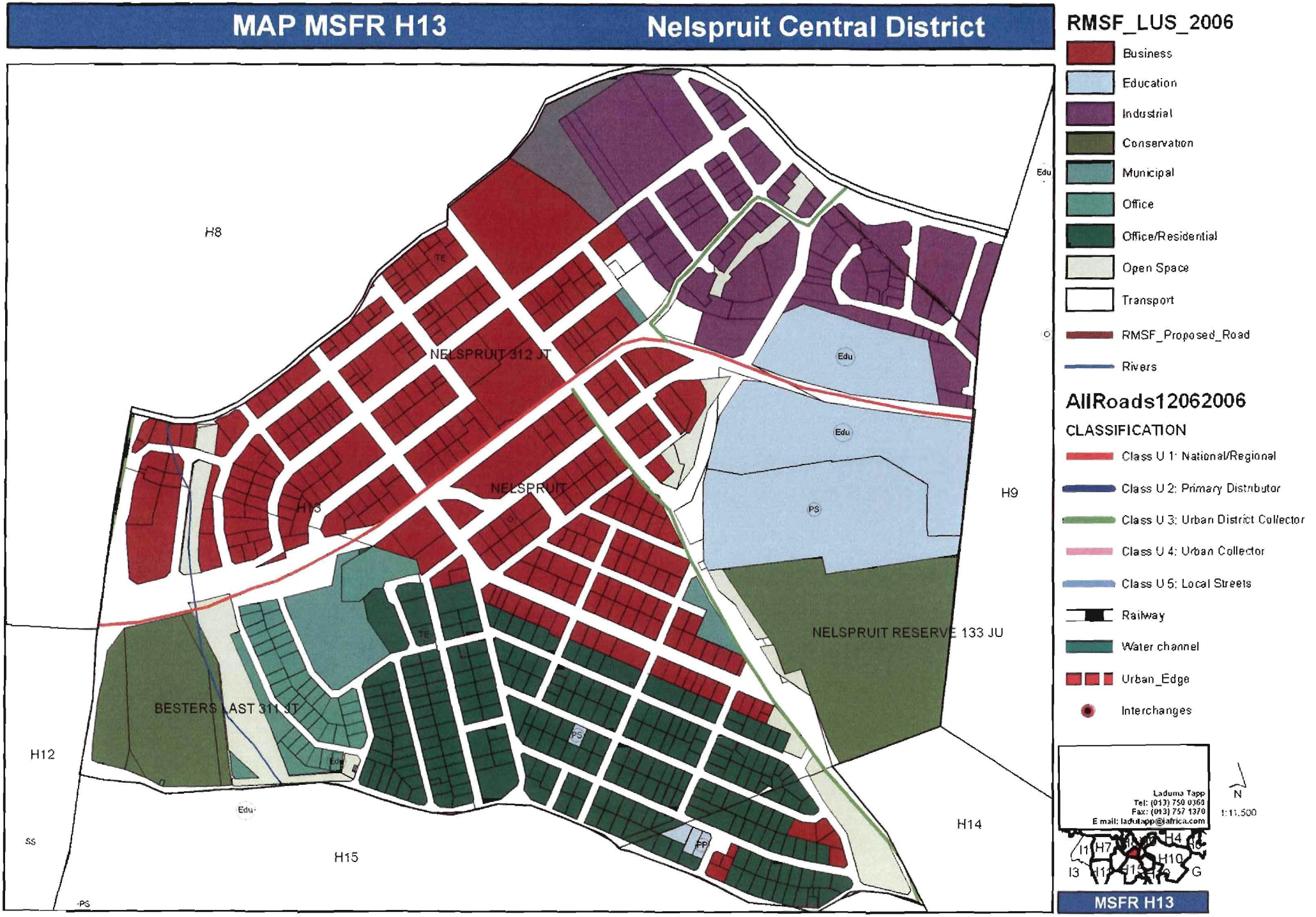


Figure 8.15: Planning Precinct H13: Nelspruit Central Business District (Laduma, 2006)

8.4.9 Precinct H14 - Nelspruit Extension

8.4.9.1 Critical Development Issues for precinct H14 (Laduma, 2006):

The precinct consists of the eastern Nelspruit Extensions residential areas including Matumi Golf Estate and Steiltes (Figure 8.16).

8.4.9.2 Development Strategies for Precinct H14 (Laduma, 2006):

The residential areas need to be protected against intrusion of non-compatible uses. Densification of the residential precincts should provide for a combination of:

- Smaller average erven sizes through the subdivision of single residential stands
- Medium-density housing in residential areas including duets, townhouses and group housing.
- Higher-density multiple-storey housing in development nodes
- Second dwelling units

8.4.9.3 Development Directives for Precinct H14 (Laduma, 2006):

Residential Use

- The maximum residential densities are applicable to the residential areas.
- Open spaces need to be functional and developments fronting onto parks should be sensitive to the character and functioning of the park and in accordance with the open spaces guidelines.

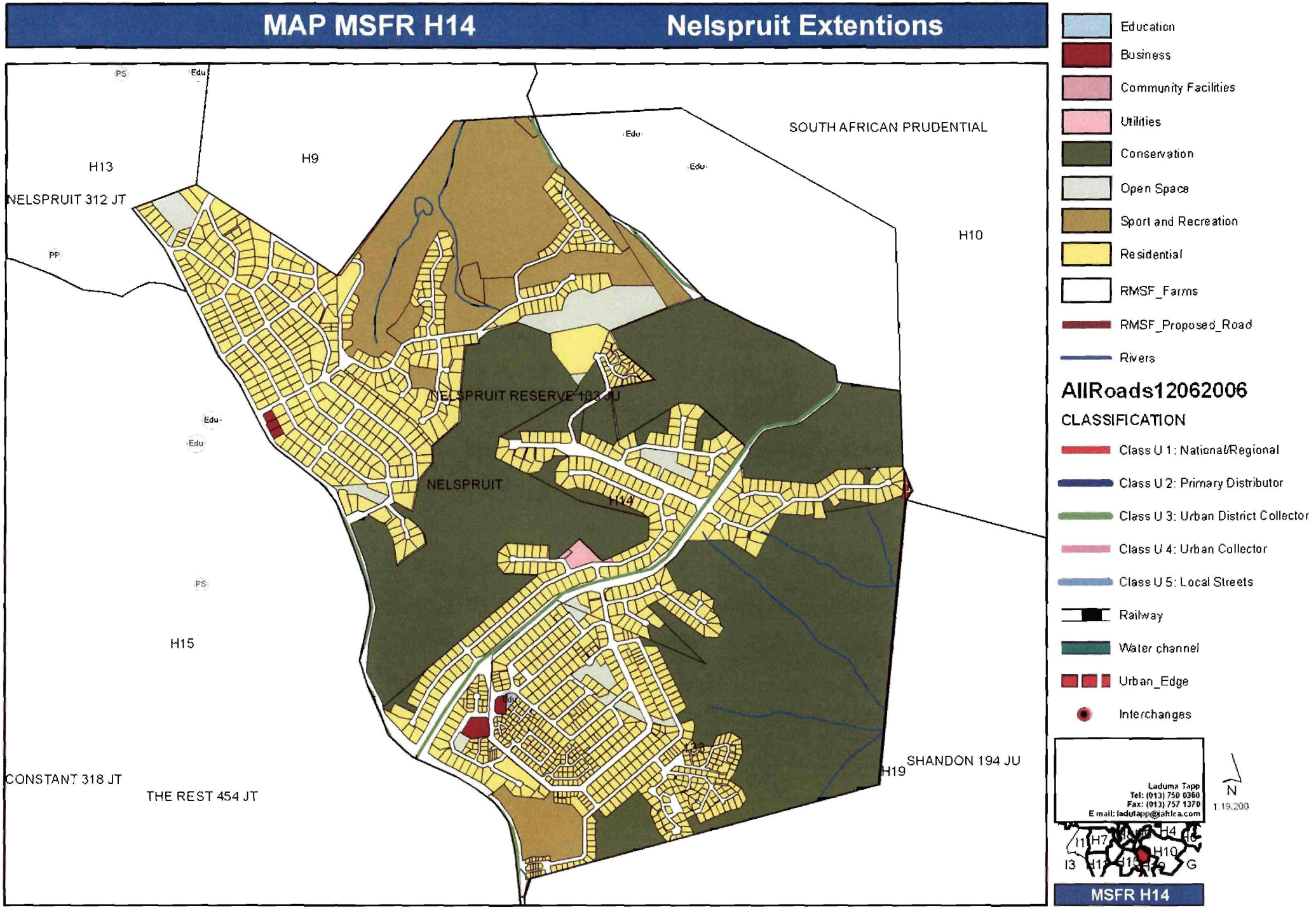


Figure 8.16: Planning Precinct H14: Nelspruit Extensions (Laduma, 2006)

8.4.10 Precinct H15 – Sonheuwel

8.4.10.1 Critical Development Issues for planning precinct H15 (Laduma, 2006):

The precinct consists of the Sonheuwel and Nelspruit Extensions residential areas (Figure 8.17: Sonheuwel Residential Area).

8.4.10.2 Development Strategies for planning precinct H15 (Laduma, 2006):

The residential areas need to be protected against intrusion of non-compatible uses. Densification of the residential precincts should provide for a combination of:

- Smaller average erven sizes through the subdivision of single residential stands
- Medium-density housing in residential areas including duets, townhouses and group housing
- Higher-density multiple-storey housing in development nodes

8.4.10.3 Development Directives for planning precinct H15 (Laduma, 2006):

Residential Use

- The maximum residential densities are applicable to the residential areas.
- Open spaces need to be functional and developments fronting onto parks should be sensitive to the character and functioning of the park and in accordance with the open spaces guidelines.

Section 8.4 included the decisions taken by the municipality for the management and planning of MLM for Planning Areas A and H. These decisions taken by the municipality are used to make recommendations in Chapter 9. The vegetation description (Chapter 4), the evaluation scores for bird and carbon storage (Chapter 6) and the environmental policies (Chapter 7) will also be used for the recommendation made in Chapter 9.

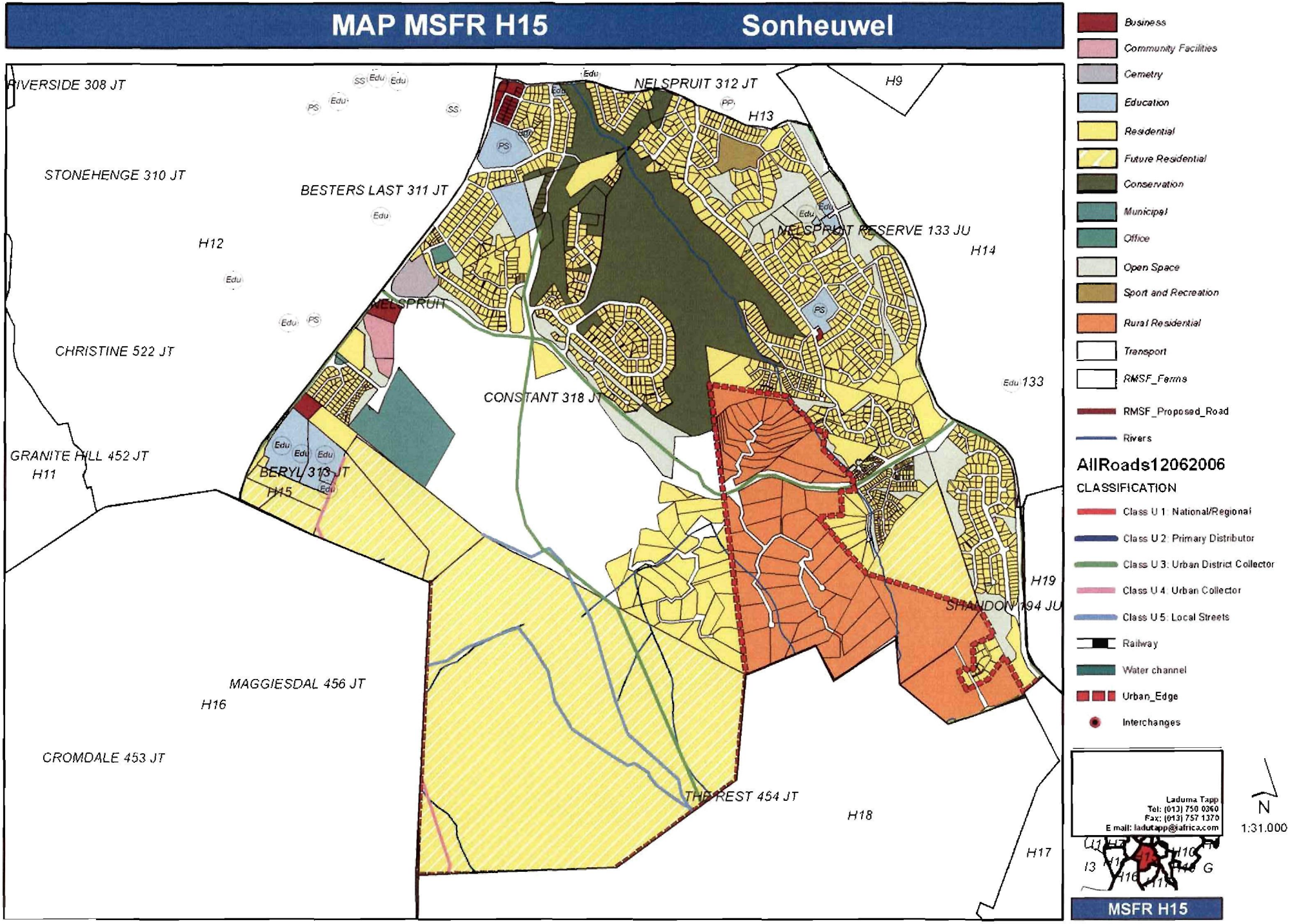


Figure 8.17: Planning Precinct H15: Sonheuwel residential Area (Laduma, 2006)

8.5 The Mbombela Draft Land Use Scheme.

The Land Use Bylaw gives the Municipality the power and duty to establish and keep a "Register of Land Use Rights" for all properties and to receive, consider and decide on all applications. Land may only be used or developed in terms of the "Land Use Rights" held in terms of the Bylaw. Land Use Rights may only be obtained or changed through the Bylaw.

The Land Use Scheme has been prepared in terms of the Mbombela Land Use Bylaw (2006) that incorporates the proclaimed jurisdiction of the Mbombela Local Municipality. The Land Use Scheme establishes all land uses, into "Land Use Purposes" and defines the purposes. Land Use Purposes indicate the orientation and compatibility of land uses and are used in spatial orientation representation. It determines aspects of development that may be regulated and visually represented on Scheme Maps. The Land Use Scheme includes the establishment of location performance criteria and General Development Criteria, which are applicable to the Precinct Plans. This includes development regulations concerning the establishment of certain types of land use, development regulations about the development envelope as well as the establishment of other general development regulations.

8.6 Conclusion

The strategy for environmental conservation in the SDF (Laduma, 2006) included the restriction of development in biologically sensitive areas, the identification of a network for open spaces, which includes areas that need to be conserved, created or rehabilitated and the provision of interfaces to protect areas from urban development. The Municipal system Act (32/2000) compelled all municipalities to developed IDPs for their areas of jurisdiction. The SDF promotes balanced development, resource optimization, accessibility and integration of land uses. The nine Planning Areas are further divided into planning precincts. Specific strategies may be adopted for each area to achieve these objectives, but no studies on biodiversity and other ecological issues in the different precincts were available for evaluation.

The Draft Land Use Scheme (LUMS) (2006) has been prepared and it is proposed that the LUMS be enforced in terms of the proposed Mbombela Land Use Bylaw (2006), which incorporates the proclaimed jurisdiction of the Mbombela Local Municipality. It includes the development of regulations concerning the establishment of certain land use types, development regulations about the development envelope, and the establishment of other general development regulations. The LUMS was not used for this study because it was insufficient and not approved by the Municipality board.

This legislation and regulations must, however, still be promulgated or implemented. In the meantime the environment is still being degraded and damaged with building activities on wetlands, uncontrolled fires in natural open spaces and decisions taken without the necessary ecological information.

This current study compares legislation, regulations and spatial planning of the municipality with ecological research done in certain Planning Precincts. The aim of this study is to assist the municipality with recommendations to improve natural open spaces in residential areas as well as to make recommendation for monitoring systems to improve the environment in residential areas. In this regard, MLM awaits the commitment and support of the relevant MECs of the Provincial Department of Land Affairs and the Department of Agriculture and Land Administration.

The protection of the environment has to be prioritized, specifically in areas where more people are concentrated (planning precincts A2, H12 and H13). Rehabilitation plans have to be part of policies, specifically in sensitive areas such as rivers and streams as well as woodlands within residential areas. All the existing policies include the strategies and plans on a broad scale, but are not adhered to. The strategies and plans have to be implemented according to timeframes. The municipality must implement plans and projects that include societies, local schools and churches.

Sustainable ecosystem management integrates social and ecological science (Pickett *et al.,* 1997). It is important to evaluate the environmental perspectives and policies of the Municipality.

CHAPTER 9



Recommendations to Assist Spatial Planning In Mbombela Local Municipality

CHAPTER 9
RECOMMENDATIONS TO ASSIST SPATIAL PLANNING IN MBOMBELA LOCAL MUNICIPALITY

9.1 Introduction

Urbanization has many deleterious ecological effects that can be mitigated by good urban design, but the first step in doing this is to quantify the ecological aspects. This has to be done on two scales: on a large scale to reduce the regional and global effects of urbanisation, and locally to make cities more attractive places in which to live (Whitford *et al.,* 2001). The results of the Mbombela SoER (Naidoo *et al.,* 2003) and the Mbombela EMF (Strategic Environmental Focus, 2006) were done on large scale and results of the current study were done on a local scale, for recommendations in the two different studied Planning Areas. Research results and biotopes maps of the current study will be readily available for planners and decision makers. Recommendations, according to research data of previous chapters and available information from the Mbombela SoER (Naidoo *et al.,* 2003), Mbombela SDF (Laduma, 2006) and Mbombela EMF (Strategic Environmental Focus, 2006), are suggested to improve and manage natural open spaces in the Mbombela Local Municipality. According to Pickett *et al.* (2001), the knowledge of nature in cities is a firm foundation for the understanding of ecological processes.

Scientists, planners and decision makers have to understand how the social, economic and ecological aspects of cities interact. Florgård (2000) suggested that, in future development areas, some natural vegetation can be utilized as parks and open spaces with proper planning. According to Nowak (1991), the energy budgets of cities are driven by fossil fuel subsidies, which contribute to the urban heat island effect. Green components of cities can affect biochemical processes and the incorporation of programmes such as species conservation programmes, for example the adoption of a wetland by schools or churches close to wetlands. The regular monitoring of open spaces by specialists such as Bird Life and the Botanical Society can improve the management plans of the MLM as well as the incorporation of specialist studies from EIA (Environmental Impact Assessment) and BA (Basic Assessment) reports.

The aim of this chapter is to give recommendations for the management of Mbombela Local Municipality to ensure that biodiversity and ecological aspects are sufficiently included in the planning policies.

9.2 Summary of the policies and documents of the Mbombela Municipality

The Mbombela SoER (Naidoo *et al.,* 2003) gives an overview of the state of the environment in Mbombela, based on indicators. Satellite imagery (Spot 4) taken in 2003 was used to assess the extent of large habitat units within Mbombela that are considered ecologically sensitive. Riparian (river) zones in urban areas are also ecologically important and sensitive habitats, but these were too narrow to be quantified from the available satellite images and therefore ignored. Broad scale investigations like the data used by Naidoo *et al.* (2003) for the Mbombela SoER can have an influence on ecological patterns that can override the local effects (Wiens, 1989). The Mbombela SoER (Naidoo *et al.,* 2003) has been used as a basis for conducting of the Mbombela SDF (Laduma, 2006), town planning and the Mbombela EMF (Strategic Environmental Focus, 2006).

The Mbombela EMF (Strategic Environmental Focus, 2006) is a decision-making support tool and has to be implemented by the authorities, developers and consultants. The ecological sensitivity was determined by, amongst others, the draft Mpumalanga Biodiversity Conservation Plan (C-Plan), environmental inventory and spatial plan developed for the Mpumalanga Province. General environmental directives in terms of ridges, alien vegetation, open spaces and ecological corridors, compiled for the Mbombela EMF (Strategic Environmental Focus, 2006) and quoted in Chapter 7, are as follows:

Ridges

No further development should take place on ridges with a slope greater than 16%. No septic tanks will be permitted and adequate water supply is required for fire protection.

Alien vegetation

All developments must ensure the removal of alien vegetation.

Open Spaces

The international standard for open spaces is 2.4 ha per 1000 members of a population. Residents bordering all open spaces must ensure that indigenous plants are used in their gardens and that these are kept as natural as possible to provide a buffer for the open spaces. No solid fencing should be allowed on the communal boundary with open spaces. Fences should allow access for species movement and linkages with other open spaces. Development applications for major roads, railway lines and pipelines must demonstrate, through alternative alignments, the connectivity of the open spaces which they intersect.

Ecological corridor

Where development is unavoidable, the developer must demonstrate how the development will have an impact on the ecological connectivity.

The Crocodile River Greenbelt Initiative Policy (Anon, 2004) prohibits some actions in general. The main purpose of these prohibitions is to protect certain open spaces from degradation, disturbances and loss of biodiversity. It is only applicable to a specific area along the Crocodile River in Nelspruit (Planning Area H).

The Draft Open Space Bylaw (Anon, 2005) could include information on the unmanaged open spaces as well. With a detailed study of the unmanaged open spaces, the MLM would be able to identify sensitive areas and prevent development in these areas. It is important to incorporate the community in the protection of unmanaged open spaces such as drainage lines. Institutions like schools, churches and some societies could also be stakeholders in projects to manage and protect open spaces.

The EIA guideline was compiled in August 2002 and focused on the procedures of an EIA process for projects undertaken under the jurisdiction of the MLM. It referred to Regulations of 1997 in terms of the Environmental Conservation Act (73/1989). This document has to be amended to comply with the new EIA Regulation of April 2006.

The Municipal Systems Act (32/2000) compelled all municipalities to developed IDPs for their areas of jurisdiction and the Mbombela SDF (Laduma, 2006) was compiled as part of the IDP. The Mbombela SDF (Laduma, 2006) promotes balanced development, resource optimization, accessibility and integration of land uses.

The Draft Land Use Scheme (Sisonke Development Planners, 2006) has been prepared and it is proposed that the LUMS be enforced in terms of the proposed Mbombela Land Use Bylaw (2006) that incorporates the proclaimed jurisdiction of the Mbombela Local Municipality. The Land Use Scheme includes the Precinct Plans and the development and minimum content of the Precinct Plans. It determines aspects of development that may be regulated and has been visually represented on Scheme Maps. It includes development regulations concerning the establishment of certain types of land use as well as development regulations about the development envelope and establishes other general development regulations.

9.3 General recommendations for MLM

The natural open spaces in Mbombela are considered to be of medium to high ecological value and the areas should to be managed carefully to protect the biodiversity in urban areas. It is necessary to plan urban areas with the consideration of sensitive areas. The protection of biodiversity, controlled carbon releases as well the aesthetic value for residents in residential urban areas are important. The following recommendations can be implemented to improve the state of open spaces and will not be discussed under each precinct:

- For the improvement of the different open spaces, fixed monitoring points that represent each biotope have to be implemented in the different planning precinct/planning areas. Data sheets of the current study can be used for evaluation and include vegetation, birds and habitat evaluation criteria. The vegetation and bird data are used for quantitative evaluations and habitat for qualitative evaluations.
- The data sheets of the current study can be used for evaluation before areas are planned for future development to evaluate whether the area is suitable for development or worthy to protect.
- Projects for rehabilitation of degraded areas in all biotopes have to be registered at MLM and advertised in the local newspaper. Local residents, societies and other companies can choose which projects they want to support.
- Training programmes for municipal workers and resident as well as at schools have to be implemented on a regular basis to teach people to protect trees so that they can grow to their full extent or potential.
- There are no small trees in open areas to replace big trees and an ongoing programme for the planting of trees has to be established in residential and other areas.

9.4 Recommendations for Planning Precinct A2: Tshabalala, Nyongane and Nkambeni

Planning Area A2 has unplanned residential and planned residential areas with high density houses and small plots (Figure 8.3). The engineering system does not provide for development, no running water and sewerage systems are available. Subsistence livestock farming is part of town planning and residents keep their livestock in their plots. Planning Area A has limited economic growth. Three of the biotopes described in Chapter 4 are present in Planning Precinct A2. They include Biotopes 1 (Rivers and streams), 2 (Hills and valleys) and 3 (Granite outcrops) (Figure 6.1).

9.4.1 Development directives for Planning Precinct A2 according to the SDF (Laduma, 2006):

- Residential development should be sustainable.
- The protection of open space should be a priority and areas within 1:100 year flood line needs to be cleared from development.
- Open spaces need to be functional and development fronting into parks should be sensitive to the character and functioning of the park. Open spaces can be used for agricultural purposes.
- The eastern parts of the area adjoining the boundary of the Kruger National Park need to be regarded as a transient zone. A Development Plan needs to be prepared.
- These areas should be protected against any development affecting them.

9.4.2 Importance rating (IR) for planning precinct A2 according to the EMF (Strategic Environmental Focus, 2006)

- Planning Area A2 has no areas which have a Very High IR which indicated that there are no irreplaceable areas that have to be protected (Figure 7.3).
- Some of the areas have an IR of High which indicates highly significant sites and wetlands.
- State land has an IR of Medium which indicates that these areas are of least concern and with disturbed vegetation, exotic plantations and/or cultivated land.
- Residential areas are rated as low IR with no remaining natural habitat with ridges and built-up areas.

9.4.3 Problems in Planning Precinct A2:

- According to the Mbombela EMF (Strategic Environmental Focus, 2006), the western part of the MLM under tribal authority is largely degraded as a result of overgrazing and poor subsistence agriculture practices.
- Soil erosion on the roads in residential areas is a huge problem.
- There is no control of illegal sand mining in Planning Area A2.
- A new development between Tshabalala and Nyongane is planned on an area that was rated High IR and streams within that area are ignored.
- Wetlands, streams and rivers are not taken into account with planning, despite the directives in the Laduma (2006).
- The Mbombela EMF (Strategic Environmental Focus, 2006) IR is not applicable in residential areas with high ecological value or sensitive vegetation, and state lands that have ridges and wetlands are rated as medium IR.

9.4.4 Recommendations for Planning Precinct A2:

The three biotopes, namely Biotopes 1 (Rivers and streams), 2 (Hills and valleys) and 3 (Granite outcrops) are represented in this planning precinct. Biotopes 1 and 3 are rated as having medium ecological value and need to be rehabilitated. Management plans have to be implemented for protection of these natural open spaces. Biotope 2 is rated as having high ecological value. Management plans have to be implemented and these areas have to be identified as protected areas under the Open Space Bylaw.

Biotope 1 in Planning Precinct A2 is represented by Plant Community 4 which has high rating values for indigenous species, carbon storage, nesting and feeding guilds. RDL plant species present in Biotope 1 are *Bridelia cathartica* and *Gladiolus hollandi.* These species have to be regularly monitored and management plans for these open areas must protect them from degradation. Although declared weeds have a low rating in Planning Precinct A2, the abundance of declared weeds is the result of human impacts and therefore an ongoing plan to stop declared weeds needs to be in place. Trees have to be protected for bird diversity that has a low rating (2) (Table 6.2) and future plans to plant trees are important. Tall trees can also enhance air quality in this Planning Precinct that does not have electricity. Sand mining is a problem in the riverbeds of the Sand River and more inspections have to be done to control this.

Biotope 2 is represented by Plant community 7 and has high ecological ratings for species richness, indigenous species, declared weeds and carbon storage. One RDL plant species was recorded in Planning Precinct A2, namely *Combretum collinum.* Although destruction of vegetation was visible, this community had the highest average of species per sampling plot (60), with no declared weeds, probably because of the Working for Water project in the Hazyview area (Working for Water, 2001b). Trees are stunted, burned or chopped, and residents have to be trained to manage trees to grow to their full extent and a programme needs to be implemented to plant trees to replace trees that have been removed.

Biotope 3 is represented by Plant Community 8 and although these relevés were relatively small; it has high ratings for species richness, indigenous species and declared weeds. The granite outcrops are isolated, but are connected with the hills and valleys.

The rehabilitation of state land and the protection from uncontrolled agricultural activities have to be managed by the implementation of management plans.

9.5 Recommendations for Planning Precinct H3: Riverside development node

The Riverside Park Development Precinct is a regional business node. The development is a strong motor vehicle related district consolidating the existing motor trade sector in a concentrated area consisting of the Riverside Industrial Park. The development of Phase 2 of the precinct will require the development of new and the upgrading of existing engineering infrastructure. The Botanical Garden (dark green) and the Greenbelt area (light green) are part of Planning Precinct H3 (Figure 8.11). According to the SDF (Laduma, 2006), several wetlands are part of this Planning Precinct, including the Nels River and the Crocodile River. The Nels River and the Crocodile River meet in the Botanical Garden and have a scenic value. According to the current study, only Biotope 1 (Rivers and streams) is present in planning precinct H3 and is rated with medium ecological value. This biotope needs to be rehabilitated and management plans have to be implemented for protection of these natural open spaces (Figure 6.2).

9.5.1 Development directives for planning precinct H3 (Laduma, 2006)

- The development of the Riverside Industrial park, business zone and low-, medium- and high density residential uses.
- The development controls on all stands must be to the satisfaction of the Mbombela Municipality.
- The Crocodile River should be regarded as a tourist recreation attraction and the utilisation thereof should take place in terms of an environmental management plan.

9.5.2 Importance rating (IR) for planning precinct H3, according to the EMF (Strategic Environmental Focus, 2006)

- Planning precinct H3 has no areas which have a Very High IR, which indicates that there are no irreplaceable areas that have to be protected (Figure 7.4).
- The Crocodile River Greenbelt has an IR of High which indicates highly significant sites and wetlands.
- Agricultural areas have an IR of Medium, which indicates that these areas are of least concern disturbed vegetation, exotic plantations and cultivated land.
- Residential and business areas are rated as low IR with no remaining natural habitat with ridges and built-up areas.

9.5.3 Problems in planning precinct H3

- According to the SDF (Laduma, 2006), several wetlands are part of this Planning Precinct, but no directives to protect the wetlands are included.

- There are no management plans or directives in the SDF (Laduma, 2006) to protect the Crocodile River Greenbelt area. It is earmarked as a tourist attraction and development needs and EIA.
- High density residential use and industries are part of this planning precinct with no directives to protect these highly sensitive areas.

9.5.4 Recommendations for planning precinct H3

Biotope 1 in planning precinct H3 is represented by Plant Community 1 that included indigenous tree species such as *Breonadia salicina* (also the dominant species) and *Syzygium cordatum,* exotic tree species such as *Morus nigra* and *Melia azedarach,* shrubs such as *Caesalpinia rostrata* and *Ludwigia octovalvis* and forbs such as *Dietes* species, *Verbena venosa* and *Oxalis corniculata. Melia azedarach* is a declared invader and poisonous to humans (Henderson, 2001). According to the rating of ecological value, planning precinct H3 has the highest rating values for carbon storage, total birds and nesting guilds. The high presence of declared weeds is the result of human impacts and therefore a detailed management plan needs to be put in place together with WFW to eradicate these weeds. The Crocodile River Greenbelt Initiative Policy that is managed by MLM is part of this planning precinct and has to be rehabilitated and managed according to management plans.

The total birds and nesting guilds have high ratings (Table 6.2) and trees have to be protected for the bird diversity. Plant Community 1 has the highest trees and tree planting programmes have to be implemented to keep the high diversity of trees for carbon storage, especially next to the high industrial area.

9.6 Recommendations for Planning Precinct H7: Sport zone / Gateway

This precinct consists of the Halls Gateway tourism business centre, the Mpumalanga Parks Board offices, TRAC offices, Hall's offices and residential area, Mataffin Villages, informal developments, extensive agriculture and open spaces that are to be integrated into an urban framework providing for the Soccer 2010 Sport Stadium (Figure 8.12). Future development includes residential development, with associated supportive businesses and commercial development. The Crocodile River tails through this planning precinct. Three biotopes, namely Biotopes 1 (Rivers and streams), 2 (Hills and valleys) and 3 (Granite outcrops) are represented in this planning precinct (Figure 6.2).

9.6.1 Development directive for Planning Precinct H7 (Laduma, 2006)

- The responsible management and protection of sensitive natural environments.

- Sensitive natural environments should be protected against any development affecting these areas. Development should only be allowed after formal procedures, as specified in environmental legislation, have been conformed with.
- A site development plan has to be approved by the municipality involving the design and functional utilisation of the site.
- Sand mining can only take place after the necessary consent of the Department of Minerals and Energy has been obtained.
- An environmental management plan, headed by an Environmental Impact Assessment, which includes control measures and development directives, should be provided with every new development or change in land use.

9.6.2 Importance rating (IR) for planning precinct H7, according to the EMF (Strategic Environmental Focus, 2006)

- Planning precinct H7 has no areas which have a Very High IR, which indicates that there are no irreplaceable areas that have to be protected (Figure 7.4).
- The Crocodile River has an IR of High, which indicates highly significant sites and wetlands.
- Agricultural areas have an IR of Medium which indicates that these areas are of least concern disturbed vegetation, exotic plantations and cultivated land.
- Residential and business areas are rated as low IR with no remaining natural habitat with ridges and built-up areas.

9.6.3 Problems in Planning Precinct H7

- The Mbombela SDF (Laduma, 2006) directives included the protection of sensitive natural areas against any development affecting these sensitive areas, but are not implemented. The soccer stadium and the Mpumalanga Parks Board offices were built on wetlands.
- Future development of the Soccer 2010 facilities will have a negative affect on the natural environment.
- Biotopes 1 and 3 are rated as having medium ecological value and need to be rehabilitated. Management plans have to be implemented for the protection of these natural open spaces.
- Biotope 2 is rated as having high ecological value. Management plans have to be implemented and these areas have to be identified as protected areas under the Open Space Bylaw. Biotope 3 is isolated but is connected with the hills and valleys and therefore it have to be included in the management plans of biotope 2.

9.6.4 Recommendations for Planning Precinct H7

This planning precinct consists of Plant Communities 2 and 5 and is characterized by a high cover of exotic declared weeds such as the dominant species *Lantana camara, Solanum mauritanum, Cardiospermum grandiflorum, Tecoma stans, Achyranthus aspera* and *Sesbania punicea.*

According to the ecological value rating (Chapter 8), Planning Precinct H3 has the highest possible value for indigenous species, carbon storage, total birds and nesting guilds. The high presence of declared weeds is the result of human impacts; especially the fruit processing plant, and therefore a detailed management plan needs to be implemented together with WFW, the fruit processing plant and the MLM to ameliorate the situation. The Crocodile River Greenbelt Initiative Policy that is managed by MLM should be extended to protect this part of the Crocodile River as well.

The total birds and nesting guilds have high ratings (Table 6.2) and trees have to be protected for the bird diversity. Plant Community 1 has the highest trees and tree planting programmes have to be implemented to keep the high diversity of trees for carbon storage, especially next to the high industrial area. More specific investigations have to identify sensitive areas, eg a wetland delineation to protect the remaining wetlands within Planning Precinct H7. Other sensitive areas such as woodlands and exposed granite outcrops, identified by the specific investigations and biotope mapping in this planning precinct, could be protected against development with mitigation measures.

9.7 Recommendations for Planning Precinct H8: Nelspruit Industrial/Commercial

Most of the stands within these areas are already developed. Further development within the Nelspruit Industrial / Commercial Areas can only take place through a process of densification. The ARC agricultural research centre and heavy industrial activities are in this planning precinct. The Nelspruit Showground, Croc River Enviro Centre, Lowveld Botanical Gardens and the surrounding underutilized land provide the opportunity of creating a tourism node as part of the Crocodile River Open Space System (Figure 8.13). Biotopes1 (rivers and streams), with some of the streams in this area highly invaded with declared weed (Table 4.5), 2 (Hills and valleys) and 3 (Granite outcrops) are present in this planning precinct. Biotopes 1 and 3 are rated as having medium ecological value and need to be rehabilitated. Management plans have to be implemented for protection of these natural open spaces. Biotope 2 is rated as having high ecological value. Management plans have to be implemented and these areas have to be identified as protected areas under the Open Space Bylaw. Biotope 3 is isolated but is connected with the hills and valleys (Figure 6.2).

9.7.1 Development directive for planning precinct H8 (Laduma, 2006)

The development of industrial stands must not be restricted and must be allowed to develop to its full potential. Where industrial areas front onto open spaces, the owners/developers of properties must be encouraged with the approval of the site development plan and building plans:

- To provide a landscaped buffer (5m) on the boundary facing the open space.
- To attend to the elevation treatment of buildings facing the park.
- Noxious industries may be allowed in heavy industrial areas subject to all the relevant environmental legislation being adhered to.
- Heavy industrial uses should be restricted to the existing demarcated areas.
- The land can be used for research and educational purposes.
- The tourism development zone should adhere to the following development guidelines:
- The land uses should be restricted to tourism activities and uses ancillary and complementary thereto. A site development plan has to be approved by the municipality for the design and functional utilization of the site.
- A Development Plan needs to be prepared involving the following actions in order to ensure the integration of the surrounding land uses:
- Assessment of existing environmental factors.

9.7.2 Importance rating (IR) for planning precinct H8 according to the EMF (Strategic Environmental Focus, 2006)

- Planning precinct H3 has no areas which have a Very High IR, which indicate that there are no irreplaceable areas that have to be protected (Figure 7.4).
- The Crocodile River has an IR of High, which indicates highly significant sites and wetlands.
- Agricultural areas have an IR of Medium, which indicates that these areas are of least concern regarding disturbed vegetation, exotic plantations and cultivated land.
- Residential and business areas are rated as low IR, with no remaining natural habitat with ridges and built-up areas.

9.7.3 Problems in Planning Precinct H8

- This area has tourism potential, but the accessibility to the area needs to be enhanced.
- Pollution from industries in the close vicinity of the agricultural area and botanical gardens could have an impact on the environment.
- Water management of the streams close to the industrial area could be polluted without regular monitoring.

- Black dust from the MMC Company could possibly have an effect on the vegetation close to the company.
- Declared weeds within riparian areas.

9.7.4 Recommendations for Planning Precinct H8

The land use of adjacent areas did have an impact on the species composition of this community and were the result of direct anthropogenic influences. People were washing their clothes in the stream next to the industrial area, while a bad smell and refuse dumping were apparent in other stream. Plant Community 2 consists of indigenous tree species such as *Ficus sur* and *Trichillia emetica* and indigenous forbs such as *Sida spinosa*. Other important invaders and declared weeds are *Tecoma stans*, *Ricinus communis*, *Solanum mauritianum* and *Lantana camara*.

Biotope 1 has a high presence of declared weeds which is the result of human impacts and therefore an ongoing plan to eradicate declared weeds needs to be in place in corporation with the industries, WFW and interested societies. Trees have to be protected for bird diversity that has a low rating (2) (Table 6.2) and future plans to plant trees are important. Tall trees can also enhance air quality in this planning precinct that does not have electricity.

Biotope 2 is represented by Plant Community 5 and has high ecological ratings for species richness, indigenous species, declared weed and carbon storage. One RDL plant species was recorded in Planning Precinct H8, namely *Gladiolus hollandii*. Trees were relatively tall (6m) but a programme to plant trees to replace the fully grown trees needs to be implemented.

Biotope 3 is represented in relatively small, isolated areas, but is connected with the hills and valleys. Management of these areas has to be incorporated with the management of Biotope 2.

9.8 Recommendations for Planning Precinct H12: West Acres Residential area

This precinct is the West Acres Residential area. The residential areas need to be protected against intrusion of non-compatible uses (Figure 8.14). All four biotopes are represented in this planning precinct (Figure 6.2). Some of the streams in this area are highly invaded with declared weeds (Table 4.5).

9.8.1 Development directive for planning precinct H12 (Laduma, 2006)

- Maximum residential densities are applicable to the residential areas.

- Open spaces need to be functional and developments fronting onto parks should be sensitive to the character and functioning of the park and in accordance with the open spaces guidelines.

9.8.2 Importance rating (IR) for planning precinct H12 according to the EMF (Strategic Environmental Focus, 2006)

- Planning precinct H12 has no areas which have a Very High IR, which indicates that there are no irreplaceable areas that have to be protected (Figure 7.4).
- Areas in planning precinct H12 have an IR of Medium to High, which indicates that these areas are important and necessary.
- Residential and business areas are rated as Low IR with no remaining natural habitat with ridges and built-up areas.

9.8.3 Problems for planning precinct H12

- Alien vegetation in streams that spread to the rivers.
- Waste management in the highly populated area can have an influence on the streams where the residents dump their garden and general waste (Figure 2.12).
- The development next to Mecure Hotel, on the Kaapschehoop road next to the church and the development in Stonehenge Ext 3 were developed on wetlands (Figure 2.11).
- Declared weed within riparian areas.

9.8.4 Recommendations for planning precinct H12

There were two separate vegetation units for Biotope 1, the vegetation on the banks of the streams (trees, shrubs, forb and grass) and the vegetation in the streams (*Phragmites australis*). It was classified together as riparian vegetation due to the definite growth form of *Acacia sieberiana* on the banks and *Phragmites australis* in the streams as seen on the aerial photo. Some of the sites were highly disturbed with garden and domestic waste. There was also evidence of burning in some areas. Homeless people spending the night in the riparian areas have caused regular burning during the winter, as well as the bad smell in these areas. Streams between residential areas have a high presence of declared weeds which is the result of human impacts and therefore an ongoing plan to stop declared weeds needs to be implemented in corporation with the WFW, societies and interested residents. Trees have to be protected for bird diversity which has a high rating (4) (Table 6.2) and future plans to plant trees are important. Tall trees can also enhance air quality in this planning precinct.

Biotope 2 is represented by Plant Community 5 and has high ecological ratings for species richness, indigenous species, declared weed and carbon storage. One RDL plant species was recorded in Planning Precinct H8, namely *Gladiolus hollandii.* Trees were relatively tall (6m) but a programme to plant trees to replace the fully grown trees needs to be implemented. Biotope 3 lies in relatively small, isolated areas, but is connected with the hills and valleys. Management of these areas have to be incorporated with the management of Biotope 2.

Biotope 4 occurs on the top of hills or in lower lying areas between the hills. The differential species include *Lannea edulis, Veronica barbatonitis, Sebaea grandis, Felicia mossamedensis, Bothriochloa insculpta, Corchorus asplenifolius,* and *Berkheya setifera.* The dominant species was *Lantana camara* (Species group AN, Table 4.1).

Street trees and gardens have to be part of the network. To protect and conserve drainage lines within the residential area, the MLM has to get residents involved in projects to protect streams, drainage lines or wetlands close to their residences. BirdLife, the Botanical Society, the Plant Specialist group and Working for Water can be involved with specialist advice.

9.9 Recommendations for Planning Precinct H13: Nelspruit Central Business District (CBD)

The N4 route passes through the Nelspruit CBD, resulting in the movement of national and regional traffic. A bypass for heavy vehicles around Nelspruit needs to be provided without compromising the regional and local accessibility of the Precinct. The future development and growth of the area will require positive public as well as private intervention in order to create sustainable investment and business confidence within the area. These interventions require proper planning, direction and application of funding, capital, infrastructure as well as natural resources on a local as well as regional level. This requires the institution of a proper local institutional development framework which will provide the optimal interaction between government, the private sector and the community (Figure 8.15). Biotope 1 (Rivers and streams) is present in Planning Precinct H13 (Figure 6.2). Streams in this area are highly invaded with declared weeds with an average of 22% declared weeds (Table 4.5).

9.9.1 Development directive for Planning Precinct H13 (Laduma, 2006)

- High-density housing needs to be provided within the CBD.
- The site development plans for offices and residential buildings should attend to the privacy of residential buildings.

- A maximum height of two (2) storeys; and
- At least 15% of the area of the erf should be landscaped to the satisfaction of the Council.

9.9.2 Importance rating (IR) for Planning Precinct H13 according to EMF (Strategic Environmental Focus, 2006)

- Planning precinct H13 has no areas which have a Very High IR, which indicates that there are no irreplaceable areas that have to be protected (Figure 7.4).
- Residential and business areas are rated as Low IR with no remaining natural habitat with ridges and built-up areas.

9.9.3 Problems for Planning Precinct H13

- Rivers and streams in this planning precinct are highly invaded by declared weeds.
- The stream from the Nature Reserve goes through the precinct and high density multiple storey housing was built next to the stream.

9.9.4 Recommendations for Planning Precinct H13

Biotope 1 in Planning Precinct H13 is represented by Plant Community 3 that was identified on the banks of the streams in Nelspruit's CBD and residential areas. Some streams are seasonal and flow only during the summer, while others flow throughout the year. The streams flowing to the Crocodile River have a slope of about 5%. There are two separate vegetation units, the vegetation on the banks of the streams (trees, shrubs, forbs and grasses) and the vegetation in the streams (*Phragmites australis*). It was classified together as riparian vegetation due to the definite growth form of *Acacia sieberiana* on the banks and *Phragmites australis* in the streams, as seen on the aerial photo. Some of the sites were highly disturbed with garden and domestic waste. There was also evidence of burning in some areas. Homeless people spending the night in the riparian areas have caused regular burning during the winter, as well as the bad smell in these areas.

This community has one of the lowest species diversities, an average of 32 species per relevé and the highest percentage of declared weeds (18%), probably as a result of direct anthropogenic influences (Table 4.5).

The total birds and nesting guilds have low ratings (2) (Table 6.2) and trees have to be protected for the bird diversity. Plant Community 1 has the highest trees and tree planting programmes have to be implemented to keep the high diversity of trees for carbon storage, especially next to the industrial area.

Other recommendations included:

- Reconsider decisions where permission was given to develop within sensitive areas.
- Get residents involved in projects to protect streams and hills in the area.
- Classify streams and hills as high IR.

9.10 Recommendations for Planning Precinct H14: Nelspruit Extension

The precinct consists of the eastern Nelspruit Extensions residential areas including Matumi Golf Estate and Steiltes (Figure 8.16). Biotopes 1 (Rivers and streams), 2 (Hills and valleys) and 3 (Granite outcrops) are represented in planning precinct H14 (Figure 6.2).

9.10.1 Development directive for planning precinct H14 (Laduma, 2006)

- The maximum residential densities are applicable to the residential areas.
- Open spaces need to be functional and developments fronting onto parks should be sensitive to the character and functioning of the park and in accordance with the open spaces guidelines.

9.10.2 Importance rating (IR) for Planning Precinct H14 according to EMF (Strategic Environmental Focus, 2006)

- The Nelspruit Nature reserve is rated as Very High IR, irreplaceable sites (Figure 7.4).
- Hills and ridges are classified as High IR, which indicates highly significant sites.
- Residential and business areas are rated as Low IR with no remaining natural habitat with ridges and built-up areas.

9.10.3 Problems for Planning Precinct H14

- The Golf course has the most birds counted in the residential area of Nelspruit and has to be rated as high importance for conservation. Trees on the golf course are fully grown and have to be protected.
- Most of the exposed granite outcrops are in this precinct and are not rated as important.
- Development of residential areas within the hills (Nelspruit Ext 46) is a problem although the SDF (Laduma, 2006) stated that open spaces have to be functional.
- The development on hills close to the Nelspruit Reserve can have an influence on the runoff of water to the stream that trails through the Reserve.

9.10.4 Recommendations for Planning Precinct H14

There were two separate vegetation units for Biotope 1, the vegetation on the banks of the streams (trees, shrubs, forbs and grasses) and the vegetation in the streams (*Phragmites australis*). These were classified together as riparian vegetation due to the definite growth form of *Acacia sieberiana* on the banks and *Phragmites australis* in the streams as seen on the aerial photo. Some of the sites were highly disturbed with garden and domestic waste. There was also evidence of burning in some areas. Homeless people spending the night in the riparian areas have caused regular burning during the winter, as well as the bad smell in these areas. Streams between residential areas have a high presence of declared weeds which is the result of human impacts and therefore an ongoing plan to stop declared weeds needs to be implemented in corporation with the WFW, societies and interested residents. Trees have to be protected for bird diversity, which has a high rating (4) (Table 6.2) and future plans to plant trees are important. Tall trees can also enhance air quality in this planning precinct.

Biotope 2 is represented by Plant Community 5 and has high ecological ratings for species richness, indigenous species, declared weed and carbon storage. One RDL plant species was recorded in Planning Precinct H8, namely *Gladiolus hollandii.* Trees were relatively tall (6m) but a programme to plant trees to replace the fully grown trees needs to be implemented. Biotope 3 lies in relatively small areas and is isolated, but is connected with the hills and valleys. Management of these areas have to be incorporated with the management of Biotope 2.

Biotope 4 occurs on the top of hills or lower lying areas between the hills. The differential species include *Lannea edulis, Veronica barbatonitis, Sebaea grandis, Felicia mossamedensis, Bothriochloa insculpta, Corchorus asplenifolius*, and *Berkheya setifera.* The dominant species was *Lantana camara.* It is recommended that no development should be allowed within this area to ensure the promotion of biodiversity and the connection of the open spaces (network of open spaces). Any further development can have an influence on the Nature Reserve.

Street trees and gardens have to form part of the network. To protect and conserve drainage lines within the residential area, the MLM has to get residents involved in projects to protect streams, drainage lines or wetlands close to their residences. BirdLife, the Botanical Society, the Plant Specialist group and Working for Water can be involved with specialist advice.

9.11 Recommendations for Planning Precinct H15: Sonheuwel

The precinct consists of the Sonheuwel and Nelspruit Extensions residential areas (Figure 8.17: Sonheuwel Residential Area). All four biotopes identified are present in Planning Precinct 15 (Figure 6.2).

9.11.1 Development directive for Planning Precinct H15 (Laduma, 2006)

- The maximum residential densities are applicable to the residential areas.
- Open spaces need to be functional and developments fronting onto parks should be sensitive to the character and functioning of the park and in accordance with the open spaces guidelines.

9.11.2 Importance rating (IR) for Planning Precinct H15 according to EMF (Strategic Environmental Focus (2006)

- Planning precinct H15 has no areas which have a Very High IR, which indicates that there are no irreplaceable areas that have to be protected (Figure 7.4).
- Areas in planning precinct H15 have an IR of Medium to High, which indicates that these areas are important and necessary.
- Residential and business areas are rated as Low IR with no remaining natural habitat with ridges and built-up areas.

9.11.3 Problems for Planning Precinct H15

- Extremely sensitive areas that are small, such as drainage lines/streams and exposed granite outcrops are not protected.
- Although the SDF (Laduma, 2006) promotes the protection of open space, not much attention was given to protect or conserve these open areas such as the grasslands that have already been destroyed by residential development.
- Areas that are indicated as open spaces have already been developed.

9.11.4 Recommendations for Planning Precinct H15

There were two separate vegetation units for Biotope 1, the vegetation on the banks of the streams (trees, shrubs, forbs and grasses) and the vegetation in the streams (*Phragmites australis*). It was classified together as riparian vegetation due to the definite growth form of *Acacia sieberiana* on the banks and *Phragmites australis* in the streams as seen on the aerial photo. Some of the sites were highly disturbed with garden and domestic waste. There was also evidence of burning in some areas. Homeless people spending the night in the riparian areas have caused regular burning

during the winter, as well as the bad smell in these areas. Streams between residential areas have a high presence of declared weeds which is the result of human impacts and therefore an ongoing plan to stop declared weeds needs to be implemented in corporation with the WFW, societies and interested residents. Trees have to be protected for bird diversity, which has a high rating (4) (Table 6.2) and future plans to plant trees are important. Tall trees can also enhance air quality in this planning precinct.

Biotope 2 is represented by Plant community 5 and has high ecological ratings for species richness, indigenous species, declared weed and carbon storage. One RDL plant species was recorded in Planning Precinct H8, namely *Gladiolus hollandii.* Trees were relatively tall (6m) but a programme to plant trees to replace the fully grown trees needs to be implemented. Biotope 3 lies in relatively small areas and is isolated, but is connected with the hills and valleys. Management of these areas have to be incorporated with the management of Biotope 2.

Biotope 4 occurs on the top of hills or in lower lying areas between the hills. The differential species include *Lannea edulis, Veronica barbatonitis, Sebaea grandis, Felicia mossamedensis, Bothriochloa insculpta, Corchorus asplenifolius,* and *Berkheya setifera.* The dominant species was *Lantana camara.*

Street trees and gardens have to form part of the network. To protect and conserve drainage lines within the residential area, the MLM have to get residents involved in projects to protect streams, drainage lines or wetlands close to their residences. BirdLife, the Botanical Society, the Plant Specialist group and Working for Water can be involved with specialist advice.

9.12 Conclusion

The policies and documents of MLM do address environmental issues, but they are not implemented by the municipality's decision makers. The low number of indigenous species in the Crocodile River Greenbelt area is one of the issues that are ignored in there management plans. Development in wetlands in Planning Precinct 12 is another issue ignoring strategies mentioned in the Mbombela SDF (Laduma, 2006).

The Draft Open Space policy does not mentioned the conservation of biodiversity, while the human aspects are well described. Natural open spaces and the management thereof have to be protected in the Open space bylaw and especially in the Mbombela SDF (Laduma, 2006). Instances of developments in wetland happed more than once, although the Mbombela SDF

(Laduma, 2006) indicates that wetlands have to be protected. Before any development is approved the evaluation form of this current study should be use to prevent incidents like previously mentioned

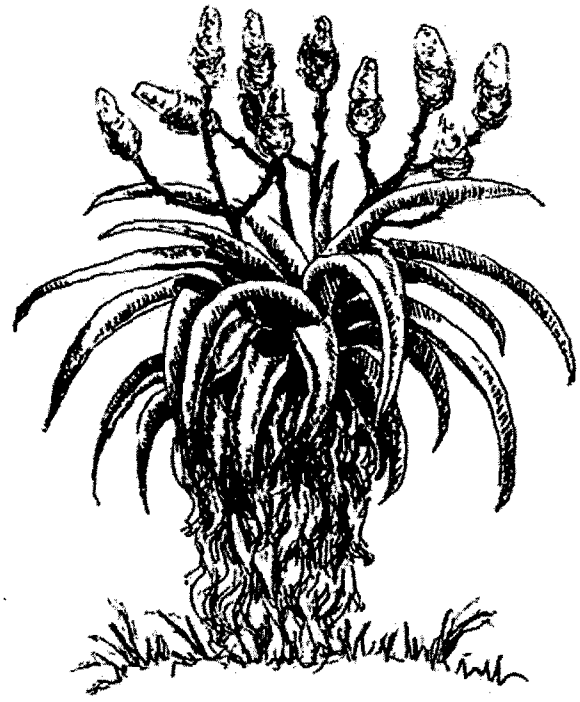
According to this study, the Crocodile River is heavily infested with declared weeds and alien spp (79% indigenous species, Table 4.5) that could be because of the many garden refuse deposits in waterways (streams in open urban areas). Therefore is it important to have a proper management system for garden refuse that is deposited in open spaces. I recommended a system of open spaces for MLM according to the findings of Bell *et al.* (2007) that classified and described the different spaces as follows: Parks and Gardens, Natural and semi-natural spaces, Green corridors, Outdoor sports facilities, Amenity green spaces.

Four Red Data species were found in Mbombela, although more Red Data species were listed in the Mbombela SoER (Naidoo *et al., 2003)* probably because of the broad scale Naidoo *et al.* (2003) were working on. Most of the birds were found in the woodlands, followed by the riparian areas. Trees should therefore be protected especially in woodlands. Trees are important for aesthetic value, temperature control and the storage of carbon in urban areas. The management and control of trees, especially in Planning Area A with short stunted trees, is important to improve carbon storage value. It is important to protect trees in Planning Area H with the many industrial activities and cars passing through Nelspruit. Most sampled areas had a high socio-economic and educational value and could be developed to educate people to make use of and conserve sensitive open spaces in residential areas.

Cilliers and Bredenkamp (2000) suggested that vegetation in urban areas can be used as a general indicator of environmental conditions and ecological processes, because urban vegetation reflects the interaction between human impacts and natural development. The findings of this study were that open spaces in Mbombela are extremely sensitive and have to form part of the management and planning of Mbombela Local Municipality. Part C of the data sheet can be used to evaluate and score natural open spaces before development decisions are taken.

With the findings of this current study and recommendations made according to the findings, the conservation and management of natural open spaces in Mbombela could be easily planned and implemented.

CHAPTER 10



Conclusion

CHAPTER 10
CONCLUSION

A comprehensive knowledge of the urban system is needed to change the general goals of the development in a city to the necessary clear guidance and targets for improvement of natural areas within the city (Pauleit and Duhme, 2000). The links between socio-economic driving forces, the functioning of the urban system and its environmental performance have to be understood. In this study the existing environmental policies and spatial development of Mbombela Local Municipality have been studied and natural open space data were evaluated. Recommendations are made to improve the ecological status of the natural open spaces.

The policies discussed were the Mbombela SoER (Naidoo *et al.,* 2003), Mbombela EMF (Strategic Environmental Focus, 2006), Crocodile River Greenbelt policy (Anon, 2004), draft open space policy (Anon, 2005) and the EIA guideline document (Anon, 2002), as well as spatial planning policies; the Mbombela SDF (Laduma, 2006) and LUMS (Sisonke Development planners, 2006). These policies described the environment, critical development issues, development strategies and the directives for development within Mbombela Local Municipality. Data were collected in open spaces in residential areas of two Planning Areas, A and H. Vegetation, bird and habitat data were evaluated to add to the current policies and spatial development directives of MLM.

The environmental policies of MLM were summarized in Chapter 7 and, according to the Mbombela SoER (Naidoo *et al.,* 2003); three sensitive habitat units were identified, namely: Natural grasslands (44%), Natural Forests (7.5%) and Wetlands (0.3%). This current study identified the similar sensitive habitats in natural open spaces of Mbombela. These were indicated in four biotopes. The Mbombela EMF (Strategic Environmental Focus, 2006) also gave high conservation values to these sensitive areas, but did not indicate residential, commercial and industrial areas where these four biotopes occur with a medium to high ecological importance. The spatial planning, SDF (Laduma, 2006) and LUMS (Sisonke Development Planners, 2006) of MLM were summarized in Chapter 8. The SDF (Laduma, 2006) estimates an average annual growth of 3.6% for 2004 -2009, 2.6% for 2009 – 2014 and 1.9% for 2014 – 2019 in Mbombela. The average annual growth rate of 3.6% for 2004-2009 for Mbombela is higher than the national growth rate of 2% for South Africa (South African Statistics, 2000) and could have a perceivable impact on the existing network of natural open spaces in Mbombela.

The first aim of this study was achieved with the investigation of natural open spaces of Mbombela that included relevés in two Planning Areas, A and H. Ten clearly recognised and ecologically interpretable plant communities were identified. The plant communities were described and grouped into four biotopes using ordination and classification techniques. These biotopes are:

1) Riparian Woodlands with river, streams and disturbed streams (Communities 1, 2, 3 and 4) (will be referred to as rivers and streams).
2) Woodlands on hills and valleys (Communities 5, 6 and 7) (referred to as hills and valleys)
3) Herbaceous Open Woodlands on exposed granite outcrops (Communities 8 and 9) (referred to as granite outcrops)
4) Grasslands (Community 10) (referred to as grasslands). (Chapter 4).

The greatest influence on ecological performance was the percentage green space, especially of trees (Biotope 1 – Rivers and streams and 2 - Hills and valleys). The bird survey indicated that trees in the natural open spaces of urban areas are important for breeding sites and the carbon storage investigation indicated that taller trees with a large biomass are important to conserve (Chapter 5). According to Nowak (1991), trees should be planted and managed because of the many benefits they provide. Trees reduce atmospheric pollutants by filtering particles, absorbing gaseous pollutants, city temperatures and energy consumption of buildings.

The second aim was achieved by the evaluation of the biotopes, as discussed in Chapter 6, which indicated that all four biotopes in natural open spaces are of some ecological importance and should be protected. Green open spaces can be used as indicators that could be a useful planning tool, facilitating the comparison of existing urban areas and helping to predict the ecological impact of new developments. Indicators also suggested that compact cities with good regional performance will inevitably have poorer performance locally because of a lack of open spaces. It is important to take human factors into consideration with spatial planning as for instance, Planning Area A; a rural residential area with agricultural activities, cannot have the same directives as Planning Area H, an urban residential area.

The third aim was achieved with the recommendations in Chapter 9, which were made according to the outcome of the findings of this study. Anthropogenic influences are incorporated to protect the environment from degradation. Awareness program and training sessions to interpret the evaluation form for ecological important areas for the personnel of the MLM are necessary. Additionally regular consultations with environmental societies such as Bird Life, the Plant Specialist Group, the Botanical Society and the Wild Life Society to upgrade information should be incorporated. The environmental statistics used in the Mbombela EMF (Strategic Environmental

Focus, 2006) are data from the Mbombela SoER (Naidoo *et al.*, 2003) and data for Mpumalanga in general. More specific research data, such as the current study and specialist studies of EIA documents, could be used to update the future environmental policies on a regular basis and to compile management plans for each biotope.

Mazzotti and Morgenstern (1997) suggested a science-based natural area management plan setting goals and objectives based on public involvement through a scoping process, resource inventories and evaluations. According to Pickett *et al.* (1997), the patterns and processes of people in urban areas are highly linked with the degree of pressure for exploiting natural resources. This responded to direct and indirect impacts from environmental insults such as air-born toxicants and exotic species. Protecting urban natural areas not only contributes to the conservation of biological diversity, but also provides valuable opportunities for human enjoyment (Mazzotti & Morgenstern, 1997). It is important for a municipality to have management plans for natural open spaces. With the compilation of management plans, the following issues have to be taken into account:

- Management plans have to be developed for each site that identifies significant resources, threats, restoration potential and public use alternatives.
- Management plans should be viewed as hypotheses of ecosystem response and monitoring programs as experiments designed to test them.
- Management plans should include provisions for modification over time as more is learned about the actual ecosystem response.

There are six aspects of future research on natural open spaces in Mbombela:

1. Include recommendations of this study in the Mbombela SDF and LUMS and continue with data collecting within these specific biotopes.
2. Do a survey on the total tree cover of Mbombela by satellite images according to the study of Yang *et al.* (2005) to use trees as an indicator for environmental degradation.
3. Research for suitable areas to plant indigenous trees every year.
4. Fixed monitoring plots for each biotope in open spaces to evaluate environmental conditions.
5. To apply management plans for biotopes in open spaces, surveys have to be done in the other planning areas in Mbombela as well.
6. Study patterns of distribution of specific birds and plants following spatial statistics and the GS++ programme according to Smith (2004).

An important shortcoming of this study was the time it took to finish the research. Some degradation on open spaces could have been prevented if the municipality had already implemented some of the recommendations. More studies that are comprehensive have to be done, especially in Planning Precinct H7 that has to accommodate many people with the soccer in 2010. The bird study has to be done more scientifically with random plots to evaluate the association of birds and trees statistically. A complete study on carbon storage of trees could be done to calculate the existing tree cover. This information can be used to improve management plans for the tree cover within the city, especially to save energy during the very hot summer months.

CHAPTER 11



Literature List

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LITERATURE LIST

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ANNEXURE A

DATA SHEETS

ASSESSMENT SHEET FOR BIOTOPE MAPPING
Mbombela -AREA

1. Relevé Number:
2. Date:
3. Surveyors:
4. Supervisor:
5. General location of the biotope:
6. Precise location (GPS):
7. Area in m^2:

8. Main Code: Term:
Detailed Code: Term:

Land use Control:

9. Photo:

10. Comment of the Photo:

A

FLORISTIC INFORMATION - BRAUN- BLANQUET - ANALYSIS

11. General information

Relevé number: size of sample plot: x = 100 m^2

12. Habitat information

Topography:

Geology:

Aspect:

Slope:

% Rockiness of soil surface:

13. Physiognomy/ Structure

	Tree layer	Shrub layer	Herb layer	
			Grass	Forb
Average height (cm)				
% Cover				

Dominant growth forms:

14. **Floristic composition**

List of species:

* = indigenous, ! = **declared** invader (cat. 1-3) m = used for medicine, f = used for food/beverages, b = used for construction/fire/skills, R = Red Data List

Grasses:	scale	Grasses:	scale
Forb:	scale	Forb:	scale
shrubs:	scale	shrubs:	scale

Trees:	scale	Height class (m)			
		0- 2	2- 5	5- 10	10- 20

B
HABITAT INFORMATION / EVALUATION DATA

[15] Networking of biotopes/ Isolation:

	Isolated	- no other natural or semi-natural biotope types nearby - isolated by dense road networks, built-up areas e.g.
	Low	- few natural or semi-natural biotope types nearby (spots, linear elements), movements or exchange possible
	Moderate	- some natural or semi-natural biotope types nearby (bigger patches, linear elements), movements or exchange are possible
	High	- many natural or semi-natural biotope types close by, mosaics of different patches around, many current interactions

[16] Impairment / human impacts in and around this plot:
(0- not existing; 1- low, 2- moderate; 3- high)

Built up areas	.....	Use for recreation	.....	Bare patches	.....
Eutrophication	.....	Destruction of vegetation	.....	Grazing	.....
Biocidal influence	.....	Refuse disposal / Soil deposit	.....	Trampling	.....
Plant invaders	.....	Soil erosion	.....	Bush encroachment	.....
Traffic	.....	Noise	.....	Bad smell	.....
Others	.....				

SUM IMPACTS :.....

[17.] Threats of adjacent biotopes:

	Very high	- serious threats present, local eradication is possible - very high value of present transformation - must act as soon as possible
	High	- substantial effects, local eradication less possible - potential changes of management in adjacent areas possible
	Moderate	- small effects on quality or distribution of habitat - no threats by current management
	Low	- no negative effect on habitat - threats will not happen in > 10 years

[18.] Socio- economic/ educational scientific value: (Average / community)
(0- not existing; 1- low, 2- moderate; 3- high)

Potential "flagship"- species*
Species with potential use for food beverages .....
Species with potential use for timber, firewood, crafts .....
Potential tourist and recreational use* .....
Species with potential medical .....
High value of wildlife/ nature education* .....

AVG / COMMUNITY (*) .....

C
EVALUATION CRITERIA AND VALUES

	Evaluation criteria	1	2	3	4
VEGETATION	Species richness (Plants)	< 20	20 - 40	41- 60	>60
	Indigenous Plants	0 – 22 %	23 – 55 %	56 – 78 %	> 79 %
	"Red Data species"	K+nt	R+I	V	E
	Declared Weeds and Invaders (%)	>19	13-18	7-12	0-6
	Carbon storage value based on Tree Height (m) + Cover (%)	1-2	3-4	5-6	7+
	Total value of vegetation				
BIRDS	Species Richness (Birds)	1-25	26-50	51-75	76+
	Red Data List (Birds)	DD + NE	NT + LC	EN + VU	RE + CR
	Feeding guild diversity	0-1	2-3	4-5	6+
	Nesting guild diversity	1-3	4-6	7-9	10-12
	Total value of birds				
HABITAT	Networking of biotopes	Isolated	Low	Moderate	High
	Human impacts	25-32	17-24	9-16	0-8
	Threats of adjacent land use	Very high	High	Moderate	Low
	Socio- economic use/ educational / scientific	0-7	8-15	16-23	24+
	Total value of habitat				
	Total Value				

Mbombela data sheet: 2004

Relevé nr:

Dabchick	8	
White-breasted Cormorant	55	
Reed Cormorant	58	
Darter	60	
Grey Heron	62	
Black-headed Heron	63	
Purple Heron	65	
Great White Egret	66	
Little Egret	67	
Cattle Egret	71	
Green-backed Heron	74	
Black-crowned Night Heron	76	
White-backed Night heron	77	
Little Bittern	78	
Hamerkop	81	
White Stork	83	
Abdim's Stork	85	
Sacred Ibis	91	
Hadeda Ibis	94	
Lesser Flamingo	97	
White-faced Duck	99	
Egyptian Goose	102	
Yellow-billed Duck	104	
African Black Duck	105	
Spur-winged Goose	116	
Black-shouldered Kite	127	
Cuckoo Hawk	128	
Bat Hawk	129	
Wahlberg's Eagle	135	
Ayres' Eagle	138	
Long-crested Eagle	139	
Martial Eagle	140	
Crowned Eagle	141	
Brown Snake Eagle	142	
African Fish Eagle	148	
Steppe Buzzard	149	

Jackal Buzzard	152	
Lizard Buzzard	154	
Little Sparrowhawk	157	
Black Sparrowhawk	158	
Little banded Goshawk	159	
African Goshawk	160	
Gymnogene	169	
Peregrine Falcon	171	
Hobby Falcon	173	
Eastern Red-footed Kestrel	180	
Lesser Kestrel	183	
Coqui Francolin	188	
Shelley's Francolin	191	
Natal Francolin	196	
Common Quail	200	
Harlequin Quail	201	
Helmeted Guineafowl	203	
Kurrichane Buttonquail	205	
Black Crake	213	
Red-chested Flufftail	217	
Buff-spotted Flufftail	218	
Moorhen	226	
Red-knobbed Coot	228	
African Finfoot	229	
African Jacana	240	
Painted Snipe	242	
Three-banded Plover	249	
Crowned Plover	255	
Black-winged Plover	257	
Blacksmith Plover	258	
Wattled Plover	260	
Common Sandpiper	264	
Green Sandpiper	265	
Wood Sandpiper	266	
Greenshank	270	
Ruff	284	

Spotted Dikkop	297	
Temminck's Courser	300	
Bronze-winged Courser	303	
Feral Pigeon	348	
Rock Pigeon	349	
Rameron Pigeon	350	
Red-eyed Dove	352	
Cape Turtle Dove	354	
Laughing Dove	355	
Green-spotted Dove	358	
Tambourine Dove	359	
Cinnamon dove	360	
Green Pigeon	361	
Brown-headed Parrot	363	
Rose-ringed Parakeet	366	
Purple-crested Lourie	371	
Grey Lourie	373	
European Cuckoo	374	
African Cuckoo	375	
Red-chested Cuckoo	377	
Black Cuckoo	378	
Striped Cuckoo	381	
Jacobin Cuckoo	382	
Klaas's Cuckoo	385	
Diderick Cuckoo	386	
Burchell's Coucal	391	
Barn Owl	392	
Wood Owl	394	
Marsh Owl	395	
Spotted Eagle Owl	401	
Fiery-necked Nightjar	405	
Freckled Nightjar	408	
Black swift	412	
White-rumped Swift	415	
Horus Swift	416	
Little Swift	417	

Alpine Swift	418	
Palm Swift	421	
Speckled Mousebird	424	
Red-faced Mousebird	426	
Narina Trogon	427	
Pied Kingfisher	428	
Giant Kingfisher	429	
Half-collared Kingfisher	430	
Malachite Kingfisher	431	
Pygmy Kingfisher	432	
woodland Kingfisher	433	
Brown-hooded Kingfisher	435	
Striped Kingfisher	437	
European Bee-eater	438	
White-fronted Bee-eater	443	
Little Bee-eater	444	
European Roller	446	
Lilac-breasted Roller	447	
Hoopoe	451	
Red-billed Wood-hoopoe	452	
Scimitar-billed Wood-hoopoe	454	
Trumpeter Hornbill	455	
Grey Hornbill	457	
Southern Yellow-billed Hornbill	459	
Black-collared Barbet	464	
Red-fronted Tinker Barbet	469	
Yellow-fronted Tinker Barbet	470	
Golden-rumped Tinker Barbet	471	
Crested Barbet	473	
Greater Honeyguide	474	
Scaly-throated Honeyguide	475	
Lesser Honeyguide	476	
Sharp-billed Honeyguide	478	
Golden-tailed Woodpecker	483	
Cardinal Woodpecker	486	

Bearded Woodpecker	487	
Olive Woodpecker	488	
Red-throated Wryneck	489	
Rufous-naped Lark	494	
Flappet Lark	496	
European Swallow,	518	
White-throated Swallow	520	
Wire-tailed Swallow	522	
Red-breasted Swallow	524	
Greater Striped Swallow	526	
Lesser Striped Swallow	527	
Rock Martin	529	
House Martin	530	
Grey-rumped Swallow	531	
Sand Martin	532	
Brown-throated Martin	533	
Black Saw-wing Swallow	536	
Black Cuckooshrike	538	
Grey Cuckooshrike	540	
Fork-tailed Drongo	541	
Black-headed Oriole	545	
Pied Crow	548	
Southern Black Tit	554	
Grey penduline Tit	558	
Arrow-marked Babbler	560	
Black-eyed Bulbul	568	
Terrestrial Bulbul	569	
Sombre Bulbul	572	
Kurrichane Thrush	576	
OliveThrush	577	
Groundscraper Thrush	580	
Familiar Chat	589	
Mocking Chat	593	
Stonechat	596	
Heuglin's Robin	599	
Natal Robin	600	
Cape Robin	601	

White-throated Robin	602	
Bearded Robin	617	
Garden Warbler	619	
Icterine Warbler	625	
Great Reed Warbler	628	
African March Warbler	631	
European March Warbler	633	
European Sedge Warbler	634	
Cape Reed Warbler	635	
Yellow Warbler	637	
African Sedge Warbler	638	
Willow Warbler	643	
Bar-throated Apalis	645	
Yellow-breasted Apalis	648	
Long-billed Crombec	651	
Green-backed Bleating Warbler	657	
Grassbird	661	
Fan-tailed Cisticola	664	
Rattling Cisticola	672	
Red-faced Cisticola	674	
Levaillant's Cisticola	677	
Croaking Cisticola	678	
Lazy Cisticola	679	
Neddicky	681	
Tawny-flanked Prinia	683	
Spotted Flycatcher	689	
Dusky Flycatcher	690	
Blue-grey Flycatcher	691	
Fan-tailed Flycatcher	693	
Black Flycatcher	694	
Fiscal flycatcher	698	
Cape Batis	700	
Chinspot Batis	701	
Fairy Flycatcher	706	
Blue-mantled Flycatcher	708	
Paradise Flycatcher	710	
African Pied Wagtail	711	

Long-tailed Wagtail	712	
Cape Wagtail	713	
Grassveld Pipit	716	
Long-billed Pipit	717	
Striped Pipit	720	
Yellow-throated Longclaw	728	
Fiscal Shrike	732	
Red-backed Shrike	733	
Southern Boubou	736	
Puffback	740	
Brubru	741	
Three-streaked Tchagra	743	
Black-crowned Tchagra	744	
Gorgeous Bush Shrike	747	
Orange-breasted Bush Shrike	748	
Olive Bush-Shrike	750	
Grey-headed Bush-Shrike	751	
White Helmet Shrike	753	
Red-billed Helmet-Shrike	754	
Indian Myna	758	
Wattled Starling	760	
Plum-coloured Starling	761	
Glossy Starling	764	
Red-winged Starling	769	
Lesser Double-collared Sunbird	783	
Greater Double-collard Sunbird	785	
White-bellied Sunbird	787	
Scarlet-chested Sunbird	791	
Black Sunbird	792	
Collared Sunbird	793	
Cape White-eye	796	
House Sparrow	801	
Grey-headed Sparrow	804	
Yellow-throated Sparrow	805	
Thick-billed Weaver	807	
Spectacled Weaver	810	

Spotted-backed Weaver	811	
Cape Weaver	813	
Masked Weaver	814	
Lesser Masked Weaver	815	
Golden Weaver	816	
Red-headed Weaver	819	
Cockoo Finch	820	
Red-billed Quelea	821	
Red Bishop	824	
Red-shouldered Widow	828	
White-winged Widow	829	
Redcollared Widow	831	
Melba Finch	834	
Green Twinspot	835	
Blue-billed Firefinch	840	
Jameson's Firefinch	841	
Red-billed Firefinch	842	
Blue Waxbill	844	
Common Waxbill	846	
Swee Waxbill	850	
Quail finch	852	
Orange-breasted Waxbill	854	
Bronze Mannikin	857	
Red-backed Mannikin	858	
Pin-tailed Whydah	860	
Black Widowfinch	864	
Purple Widowfinch	865	
Steelblue Widowfinch	867	
Yellow-eyed Canary	869	
Cape Canary	872	
Bully Canary	877	
Streaky-headed Canary	881	
Golden-breasted Bunting	884	
Rock Bunting	886	
Yellow-billed Kite	126a	

ANNEXURE B

PLANT USES

ANNEXURE B

Uses of plants found in the study areas of Mbombela Local Municipality.

Plant	Uses
Acacia ataxacantha	Baskets from strips of wood
Acacia caffra	Dye - light brown
Acacia karroo	Seed roasted, use as coffee. Dye - tanning leather. Firewood. Gum market as Cape gum - use for mouth ulcers, treat oral thrush.
Acacia sieberiana	Dye - grey
Acalypha caperonioides	Treat coughs
**Achyranthes aspera var. sicula*	Food - plant use same as spinach. Chest pains and stomach ache.
Acokanthera rotundata	Poison for hunting. All parts are highly toxic, except ripe fruit. (Schmidt, 564)
Acridocarpus natalitius	
Adenia digitata	Edible fruit
**Ageratum houstonianum*	Ornamental garden plant.
Albizia versicolor	Timber (V Wyk, 262). Purgative, kill internal worms and use roots as soap.
Alectra sessiliflora	Dye clothes and textile. Is parasitic on grass
Aloe species	Children drink nectar from the plants. Ornamental. Leaf ash is use to protect grain against weevils. Various medical uses.
**Amaranthus hybridus*	Food - plans use same as spinach.
Ancylobotrys capensis	Edible fruit.
Annona senegalensis	Edible fruit. Bark is taken for toothache.
**Anredera cordifolia*	Ornamental garden plant. (South America)
Asparagus ramosissimus	Above parts are used for colds, general body aches. Root extracts have cardio tonic, oxy-tonic and immune-stimulatory activities.
**Bambusa balcooa*	Furniture and ornamentals
Bauhinia galpinii	Decoction of the tuber is taken for pneumonia and venereal diseases and diarrhoea. Ornamental plant. Basket making and roof construction.
Berchemia zeyheri	Edible fruit. Wood - Craft work and ornamentals.
**Bidens bipinnata*	Spinach plant, pot herbs
**Bidens pilosa*	Spinach plant, pot herbs
Breonadia salicina	Timber wood.
Bridelia cathartica	Edible berries and are used medicinally.
Bridelia micrantha	Edible berries. Abortifacient. Furniture and ornamentals
Burkea Africana	Bark - heavy menstruation. Root - abdominal pain, dysentery, pneumonia and toothache. Dressing for tropical ulcers.
**Canna indica*	Ornamental
Cassia abbreviata	Tonic and mild, non-cramping laxative. Root infusion are taken orally is aphrodisiac and is used as an abortifacient.
Cassine papillosa	Bark used to clean digestive tract and for chest congestion.
Catha edulis	Tea, fencing, ornamental and timber. Medically: cold, flues, coughs, asthma. Bark - diarrhoea and dysentery. Root- male infertility.
**Catharanthus roseus*	Ornamental, medically: against diabetes, breast cancer and Hodgkin's.
**Centella asiatica*	Leaves cooked as vegetables. Medically: Treat skin complaints, fever, diarrhoea, leprosy, TB and alimentary ulcers. Anti-cancer activities. Mild tranquillizing, anti-stress

	and anti-anxiety. Wound healing.
Ceratotheca triloba	Abortifacient.
**Chloris gayana*	Grazing
Cissampelos torulosa	Leaf decoctions have been administered as an enema to treat hallucinations.
Clematis brachiata	
Cleome species	Spinach plant. Dried and stored for winter. African cabbage
Combretum apiculatum	Tea brewed from leaves, fodder tree for browsing animals, poles are cut for fencing, hut-building and fire wood..
Combretum erythrophyllum	Roots - venereal diseases. Used for ornamentals, furniture and carving.
Combretum hereroense	Firewood
Combretum imberbe	Firewood, ash used as toothpaste
Combretum molle	Make traditional grain stamping mortars. Medically: used for infertility and treat post-partum bleeding.
Commelina africana	Decoctions of the root are used for menstrual cramps.
Commelina benghalensis	Used for treating infertility in women.
Commiphora mollis	Roots are eaten for moisture. Soft timber is used to carve ornamentals and household items.
Corchorus asplenifolius	Eaten as food
Cucumis zeyheri	Eaten as food.
Cussonia spicata	Roots - source of water.
Cyanotis speciosa	Root decoctions are used for menstrual pains and to facilitate conception.
Cymbopogon excavatus	Aromatic and durable thatch.
Cymbopogon validus	Thatching grass
Cynodon dactylon	Ornamental
Cyperus albostriatus	Mat making and ornamental.
Cyperus rotundus	Perfume and medical
Cyphostemma species	Relieve pain
Dalbergia melanoxylon	Timber for ornaments, walking sticks and musical instruments.
Dicerocaryum eriocarpum	Lubricate birth canal, soap and shampoo. Applied to arrow.
Dichrostachys cinerea	Medically: diarrhoea, toothache, snake bite. Firewood.
Digitaria eriantha	Weaving material for baskets.
Dioscorea cotinifolia	Edible fruit . Root and bark used for traditional medicine.
Dioscorea sylvatica	Treat chest conditions and is contraceptive.
Diospyros lycioides	Edible fruit, toothbrush and is antibacterial, also used as chewing stick.
Diospyros mespiliformis	Eat fruit fresh. Beer brewing
Dombeya rotundifolia	Used orally or as enema to treat internal ulcers, diarrhoea and stomach problems. Bark delayed labor and chest complaints.
Drimia species	Bulbs are used as expectorants, emetics diuretics and heart tonics.
Elephantorrhiza species	Dye - Brown colour
Englerophytum magalismontanum	Food
Englerophytum natalense	Food
Eragrostis chloromelas	Make bread and beer
Eragrostis curvula	Make bread and beer
Erythrina lysistemon	Tooth- and earache and is antibacterial.
Euclea crispa subsp. Crispa	Epilepsy
Euclea divinorum	Eardrops, headache. Dental care, make toothbrush. Firewood.

Euclea natalensis	Cosmetic and refreshing taste to mouth
Euphorbia cooperi	Fish poison
Euphorbia ingens	Fish poison
Faurea rochetiana	Furniture and ornamentals
Faurea saligna	Furniture and ornamentals
Ficus glumosa	Dye- leather red colour.
Ficus sur	Food. Stop nose bleeding, root - sore throat
Ficus sycomorus	Food and dye.
Ficus thonningii	Fire sticks
Flacourtia indica	Food - jam.
Geranium species	Bladder infection
Grewia flavescens	Edible fruit - refreshing drink
Grewia monticola	Edible fruit
Haemanthus species	Dressing for sores, diuretic and for asthma.
Helichrysum nudifolium	Treat as tea for chest pains, headaches, fever, wounds and burnt for religious uses.
Helichrysum species	Aromatic perennial herbs used for ritual incense, perfume and repellent
Heteropyxis natalensis	Nose bleeding, mouth wash for toothache, mouth and gum infections
Hibiscus species	Cord and rope (bind things together)
Hyparrhenia hirta	Thatching
Hyperthelia dissoluta	Thatching
Hypoxis hemerocallidea	TB and cancer treatment. Palpitation and depression. Dye - Black.
Indigofera arrecta	Infertility treatment. Dye - purple - dark brown.
**Ipomoea alba*	Induce dreams. Ornamental
**Ipomoea purpurea*	Water source
Jasminum fluminense	Chewed to clean teeth.
Jatropha curcas	Stomach ailments, treat wounds and burns.
Kigelia africana	Applied to sores and ulcers, ingredient for cosmetics and skin lotions. Dye - Yellow.
Lannea discolor	Food. Convulsions and dizziness.
Lannea edulis	Food. Treat bilharzias and black water fever
Lannea schweinfurthii var. stuhlmannii	Food - edible fruits. Tanning and rope making.
Leonotis leonurus	Treat colds, flu, asthma, high blood pressure
Leonotis ocymifolia	Dye - pink
Leucaena leucocephala	Firewood - Fast growing plant
Leucas martinicensis	Clean teeth - making toothbrush
Lippia javanica	Aromatic, medical tea treat coughs, colds, fever. Repellent oil from seeds.
Lippia rehmannii	Aromatic, medical tea treat coughs, colds, fever. Repellent oil from seeds.
Maytenus senegalensis	Treat coughs, bronchitis, sore throat and headache.
**Melia azedarach*	Poisonous, anti-feedant properties.
Mimusops zeyheri	Edible fruits. Timber – furniture.
Momordica balsamina	Edible fruits.
Momordica foetida	Spinach plant.
Monanthotaxis caffra	Edible fruit. Tying in hut construction.
Morus alba	Edible berries
Myrothamnus flabellifolius	Flavoured tea and use as spice. Essential oils, medical tea and treat gingivitis.
Olea europaea subsp. africana	Leaves lower blood pressure. Timber - furniture.
Oxalis species	Food source

Pappea capensis	Edible fruit. Oil from nuts, used for gums and soap
Parinari curatellifolia	Edible fruit. Treat painful uterus and toothache.
Pellaea calomelanos	Dried leave - Smoke for headache, chest colds and asthma.
Peltophorum africanum	Root - abdominal pain and sore throat.
Phoenix reclinata	Palm wine and for fibre in food. Hand brooms
Phragmites australis	Baskets - large grain storage, tobacco pipe and fences
Portulaca oleracea	Ate leaves raw.
Pouzolzia mixta	Cooked as green vegetables, leaves are used as soap for hand and cloths. Used for ropes and strings. Roots - paste applied to burns. Used for infertility, urine pain, venereal diseases, contraceptive. Thin strips pf bark fibre has been used to stitch wounds.
Pseudarthria hookeri	Ornamental plant
**Psidium guajava*	Edible fruit. Leaves - fever, cough, boils, diabetes and diarrhoea. Root - scabies
Pterocarpus angolensis	Timber - Furniture, carpentry, carving
Pterocarpus rotundifolius	Timber - Furniture, carpentry, carving
Rauvolfia caffra	Tranquilizer, insomnia, headache (Raubasine)
Rhoicissus tomentosa	Edible fruit
Rhoicissus tridentata	Edible fruit. Menstrual pain and infertility. Colds, bleeding peptic ulcers, kidney and bladder. Wipe baby's bottom.
Rhus chirindensis	Leaves are chewed for post partum problems. Roots are therapeutic for infective disorder of the gastro-intestinal tract.
**Ricinus communis*	Toothache - oil of seeds are rubbed on effected areas also used for mumps.
Rubia cordifolia subsp. conotricha	Dye - orange to reddish brown colour
Sansevieria hyacinthoides	Use fibres for ropes. Earache, stomach ache, ulcers, diarrhoea.
Sarcostemma viminale	Stimulate flow of milk.
Scabiosa columbaria	Colic and heartburn
Scadoxus puniceus	Coughs and gastro-intestinal problems
**Schkuhria pinnata*	Abortifacient and contraceptive.
Schotia brachypetala	Edible seeds. Bark - Heartburn and hangovers. Dye - red-brown to red.
Schrebera alata	
Sclerocarya birrea	Edible fruit, fresh or marula beer. Nut - Oil and moisturizer for women and baby. Medically: diarrhoea, diabetes, fever, malaria. Dye - pink. Wood household items.
Selaginella dregei	Toothache
Senecio serratuloides	Wound healing
**Sesbania punicea*	Ornamental plant
Setaria sphacelata	Beer brewing with seeds, hat woven
**Solanum nigrum*	Spinach plant and jam from berries. Dye - Black to dark blue
**Sonchus oleraceus*	Spinach plant
Sporobolus fimbriatus	Food during draught
Stachys species	Treat bronchitis, asthma, insomnia
Stapelia species	Remedy for hysteria
Strychnos cocculoides	Fruit - ripe fruit pulp or dried. Timber - craft work. Medically - snake bite.
Strychnos madagascariensis	Fruit - ripe fruit pulp or dried. Timber - craft work. Medically - snake bite.
Strychnos spinosa	Fruit - ripe fruit pulp or dried. Timber - craft work. Medically - snake bite.
Syzygium cordatum	Edible berries. Medicine: stomach problems. Timber. Dye

	orange - red
**Tagetes minuta*	Dye - Gold, green, yellow and maroon. Aromatic - perfume, repellent and flavouring in food, beverage and tobacco.
Talinum caffrum	Leaves - edible like spinach
Terminalia sericea	Timber - Poles. Bark - ropes, stomach disorders and diarrhoea.
Tetradenia riparia	Fever and coughs
Trachyandra species	Cook as stew
Trichilia emetica	Cook with sweet potato. Moisturize oil and soap. Fish poison and carving. Dressing for wounds
Tylosema fassoglense	Edible pods and seed. Dye - brown (roots)
Urochloa mosambicensis	Seeds - porridge
Vangueria infausta	Fruit edible
Vernonia adoensis	Treat stomach, chest and skin complaints, head lice and back pain. Use to anoint dogs before hunting.
Vernonia natalensis	Healthy pregnancy, uterine pain
Vernonia oligocephala	Diabetes, health tonic and appetite stimulant
Vigna vexillata	Seeds and nuts - edible
Xerophyta retinervis	Asthma, stop nose bleeding anti-inflammatory.
Ximenia americana	Edible fruit, nut - oily, edible and is used for cosmetic - skin ointment and lubricant to treat leather. Bark - toothbrush, treat toothache and use as mouthwash. Leaves - eyewash, toothache and constipation.
Ximenia caffra	Edible fruit. Nut - oily, edible. Cosmetic - skin ointment. Lubricant to treat leather. Root: aphrodisiac, pregnancy nausea, wound dressing, bilharzias, pelvic and venereal diseases. Leave: infertility, fever, tonsillitis, eyewash, abdominal pain and cramps. Fruit: Juice of rotten fruit was applied to septic sores, scabies, impetigo and chicken pox (fungal growth produce antibiotics.
Xysmalobium species	Bitter roots, popular medicines: indigestion, fever, colds, abdominal cramps, diarrhoea, headaches, hysteria, treat wounds and abscesses. It has a sedative action as well as antispasmodic activity. Powered root is sprinkle on skin and hides to prevent dogs gnawing on them.
Zanthoxylum capense	Bark is removed from twigs to make toothbrush. Bark and root: flatulent colic, stomach ache, fever, toothache and mouthwash. It has anti-plaque and anti-inflammatory activity; it is use commercially in toothpaste. It selectively binds to dental plaque and inhibits bacterial growth.
Ziziphus mucronata	Edible fruit, brew beer. Root, bark and leaves are use to treat diarrhoea, dysentery, coughs and chest problems. Roots and leaves: pulped and applied on wounds, boils, sores and painful swellings.

ANNEXURE C

BIRDS LIST

Table 3.1: Bird species found in Community 4 (Relevé 3, 6, 16, 18 – Open spaces in streams and even areas in Hazyview)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
71	*Bubulcus ibis*	Cattle Egret	v	1
81	*Scopus umbretta*	Hamerkop	v	1
135	*Aguila wahlbergi*	Wahlberg's Eagle	v	1
249	*Charadrius tricollaris*	Three-banded Plover	v	5
355	*Streptopelia senegalensis*	Laughing Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
378	*Cuculus clamosus*	Black Cuckoo	ii	P
385	*Chrysococcyx klaas*	Klaas's Cuckoo	ii	P
421	*Cypsiurus parvus*	African Palm Swift	ii	2
424	*Colius striatus*	Speckled Mousebird	iv	7
426	*Urocolius indicus*	Red-faced Mousebird	iii	7
470	*Pogoniulus chrysoconus*	Yellow-fronted Tinker Barbet	iv	7
476	*Indicator minor*	Lesser Honeyguide	ii	P
483	*Campethera abingoni*	Golden-tailed Woodpecker	ii	1
486	*Dendropicos fuscescens*	Cardinal Woodpecker	ii	1
518	*Hirundo rustica*	Barn Swallow	iv	Ex
541	*Dicrurus adsimilis*	Fork-tailed Drongo	iv	1
568	*Pycnonotus tricolour*	Black-eyed Bulbul	iv	1
576	*Turdus libonyanus*	Kurrichane Thrush	iv	1
599	*Cossypha heuglini*	White-Browed Robin-chat	iv	7
645	*Apalis thoracica*	Bar-throated Apalis	ii	9
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
694	*Melaenornis pammelaina*	Southern Black Flycatcher	iv	3
710	*Terpsiphone viridis*	African Paradise-flycatcher	ii	1
732	*Lanius collaris*	Common Fiscal	iv	7
736	*Laniarius ferrugineus*	Southern Boubou	iv	7
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
747	*Telophorus quadricolor*	Gorgeous Bush Shrike	ii	6
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
787	*Cinnyris talatala*	White-bellied Sunbird	iv	7
796	*Zosterops capensis*	Cape White-eye	iv	7
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
842	*Lagonosticta Senegal*	Red-billed Firefinch	iv	8
844	*Uraeginthus angolensis*	Blue Waxbill	iv	7
857	*Lonchura cucullata*	Bronze Mannikin	iv	7
869	*Serinus mozambicus*	Yellow-fronted Canary	iv	7

Table 3.2: Bird species found in Community 6 (Relevé 4, 13, 15, 19, 21, 23 – Open spaces in even areas in Hazyview)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
71	*Bubulcus ibis*	Cattle Egret	v	1
352	*Streptopelia semitorquata*	Red-eyed Dove	iv	7
354	*Streptopelia capicola*	Cape Turtle Dove	iv	7
355	*Streptopelia senegalensis*	Laughing Dove	iv	7
358	*Turtur chalcospilos*	Green-spotted Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
391	*Centropus burchelli*	Burchell's Coucal	v	9
432	*Ispidina picta*	African Pygmy Kingfisher	v	2
435	*Halcyon albiventris*	Brown-hooded Kingfisher	v	2
444	*Merops pusillus*	Little Bee-eater	ii	2
464	*Lybius torquatus*	Black-collared Barbet	iv	1
470	*Pogoniulus chrysoconus*	Yellow-fronted Tinker Barbet	iv	1
518	*Hirundo rustica*	Barn Swallow	iv	Ex
541	*Dicrurus adsimilis*	Fork-tailed Drongo	iv	1
568	*Pycnonotus tricolour*	Black-eyed Bulbul	iv	1
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
672	*Cisticola chiniana*	Rattling Cisticola	iv	9
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
689	*Muscicapa striata*	Spotted Flycatcher	iv	Ex
728	*Macronyx croceus*	Yellow-throated Longclaw	ii	8
732	*Lanius collaris*	Common Fiscal	iv	7
736	*Laniarius ferrugineus*	Southern Boubou	iv	7
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
747	*Telophorus quadricolor*	Gorgeous Bush Shrike	ii	6
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
764	*Lamprotonis nitens*	Cape Glossy Starling	iv	3
769	*Onychognathus morio*	Red-winged Starling	iv	2
787	*Cinnyris talatala*	White-bellied Sunbird	iv	7
792	*Chalcomitra amethystine*	Amethyst Sunbird	iv	3
804	*Passer diffuses*	Southern Grey-headed Sparrow	ii	3
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
828	*Euplectes asillaris*	Fan-tailed Widowbird	iv	9
831	*Euplectes ardens*	Red-collared Widowbird	iv	9
840	*Lagonosticta rubricata*	African Firefinch	iv	9
844	*Uraeginthus angolensis*	Blue Waxbill	iv	7
857	*Lonchura cucullata*	Bronze Mannikin	iv	7
869	*Serinus mozambicus*	Yellow-fronted Canary	iv	7
886	*Emberiza tahapisi*	Cinnamon-breasted Bunting	iv	5

Table 3.3: Bird species found in Community 7 (Relevé 5, 7, 9, 10, 11, 12, 14, 17, 20, 22, 24 – Open spaces in even areas in Hazyview)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
71	*Bubulcus ibis*	Cattle Egret	v	1
81	*Scopus umbretta*	Hamerkop	v	1
148	*Haliaeetus vocifer*	African Fish Eagle	v	1
189	*Peliperdix sephaena*	Crested Francolin	vi	5
352	*Streptopelia semitorquata*	Red-eyed Dove	iv	7
355	*Streptopelia senegalensis*	Laughing Dove	iv	7
358	*Turtur chalcospilos*	Green-spotted Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
391	*Centropus burchelli*	Burchell's Coucal	v	9
421	*Cypsiurus parvus*	African Palm Swift	ii	2
424	*Colius striatus*	Speckled Mousebird	iv	7
426	*Urocolius indicus*	Red-faced Mousebird	iii	7
438	*Merops apiaster*	European Bee-eater	ii	2
464	*Lybius torquatus*	Black-collared Barbet	iv	1
470	*Pogoniulus chrysoconus*	Yellow-fronted Tinker Barbet	iv	1
474	*Indicator indicator*	Greater Honeyguide	ii	P
518	*Hirundo rustica*	Barn Swallow	iv	Ex
541	*Dicrurus adsimilis*	Fork-tailed Drongo	iv	1
545	*Oriolus larvatus*	Black-headed Oriole	iv	1
568	*Pycnonotus tricolour*	Black-eyed Bulbul	iv	1
572	*Andropadus importunes*	Sombre greenbul	iv	6
599	*Cossypha heuglini*	White-Browed Robin-chat	iv	7
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
651	*Sylvietta refescens*	Long-billed Crombec	ii	1
657	*Camaroptera brachyuran*	Green-backed Camaroptera	ii	7
672	*Cisticola chiniana*	Rattling Cisticola	iv	9
681	*Cisticola fulvicapilla*	Neddicky	ii	9
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
689	*Muscicapa striata*	Spotted Flycatcher	iv	Ex
728	*Macronyx croceus*	Yellow-throated Longclaw	ii	8
732	*Lanius collaris*	Common Fiscal	iv	7
736	*Laniarius ferrugineus*	Southern Boubou	iv	7
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
747	*Telophorus quadricolor*	Gorgeous Bush Shrike	ii	6
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
754	*Prionops retzii*	Retz's Helmet-Shrike	v	1
764	*Lamprotonis nitens*	Cape Glossy Starling	iv	3
769	*Onychognathus morio*	Red-winged Starling	iv	2
787	*Cinnyris talatala*	White-bellied Sunbird	iv	7
791	*Chalcomitra senegalensis*	Scarlet-chested Sunbird	iv	3
792	*Chalcomitra amethystine*	Amethyst Sunbird	iv	3
804	*Passer diffuses*	Southern Grey-headed Sparrow	ii	3
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
816	*Ploceus xanthops*	Golden Weaver	iv	4
828	*Euplectes asillaris*	Fan-tailed Widowbird	iv	9
840	*Lagonosticta rubricata*	African Firefinch	iv	7
857	*Lonchura cucullata*	Bronze Mannikin	iv	7
860	*Vidua macroura*	Pin-tailed Whydah	i	P

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
869	*Serinus mozambicus*	Yellow-fronted Canary	iv	7
884	*Emberiza flaviventris*	Golden-breasted Bunting	iv	7
886	*Emberiza tahapisi*	Cinnamon-breasted Bunting	iv	5

Table 3.4: Bird species found in Community 8 (Relevé 25, 30, 37, 39 – Open spaces in Granite outcrops in Hazyview)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
71	*Bubulcus ibis*	Cattle Egret	v	1
135	*Aguila wahlbergi*	Wahlberg's Eagle	v	1
169	*Polyboroides typus*	African Harrier-hawk	v	1
355	*Streptopelia senegalensis*	Laughing Dove	iv	7
358	*Turtur chalcospilos*	Green-spotted Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
424	*Colius striatus*	Speckled Mousebird	iv	7
426	*Urocolius indicus*	Red-faced Mousebird	iii	7
470	*Pogoniulus chrysoconus*	Yellow-fronted Tinker Barbet	iv	1
483	*Campethera abingoni*	Golden-tailed Woodpecker	ii	1
486	*Dendropicos fuscescens*	Cardinal Woodpecker	ii	1
518	*Hirundo rustica*	Barn Swallow	iv	Ex
541	*Dicrurus adsimilis*	Fork-tailed Drongo	iv	Ex
568	*Pycnonotus tricolour*	Black-eyed Bulbul	iv	Ex
681	*Cisticola fulvicapilla*	Neddicky	ii	9
694	*Melaenornis pammelaina*	Southern Black Flycatcher	iv	3
720	*Anthus lineiventris*	Striped Pipit	ii	8
732	*Lanius collaris*	Common Fiscal	iv	7
736	*Laniarius ferrugineus*	Southern Boubou	iv	7
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
787	*Cinnyris talatala*	White-bellied Sunbird	iv	7
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
857	*Lonchura cucullata*	Bronze Mannikin	iv	7

Table 3.5: Bird species found in Community 1 (Relevé 43,47,49,50 – Natural riparian open spaces in Nelspruit)

R No	Scientific names	Common names	Feeding Guild	Nesting Guild
71	*Bubulcus ibis*	Cattle Egret	ii	1
74	*Butorides striata*	Green-backed Heron	v	7
94	*Bostrychia hagedash*	Hadeda Ibis	v	3
105	*Anas sparsa*	African Black Duck	iv	8
249	*Charadrius tricollaris*	Three-banded Plover	v	5
266	*Tringa glareola*	Wood Sandpiper	v	E
348	*Columba livia*	Feral Pigeon	iv	2
352	*Streptopelia semitorquata*	Red-eyed Dove	iv	7
355	*Streptopelia senegalensis*	Laughing Dove	iv	7
358	*Turtur chalcospilos*	Green-spotted Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
377	*Cuculus solitarius*	Red-chested Cuckoo	iv	P
386	*Chrysococcyx caprius*	Diderick Cuckoo	ii	P
391	*Centropus burchelli*	Burchell's Coucal	v	9
421	*Cypsiurus parvus*	African Palm Swift	ii	2
424	*Colius striatus*	Speckled Mousebird	iv	7
428	*Ceryle rudis*	Pied Kingfisher	v	2
435	*Halcyon albiventris*	Brown-hooded Kingfisher	v	2
452	*Phoeniculus purpureus*	Red-billed Wood-hoopoe	iv	1
454	*Rhinopomastus cyanomelas*	Scimitar-billed Wood-hoopoe	iv	1
457	*Tockus nasutus*	Grey Hornbill	v	1
464	*Lybius torquatus*	Black-collared Barbet	iv	1
470	*Pogoniulus chrysoconus*	Yellow-fronted Tinker Barbet	iv	1
471	*Pogoniulus bilineatus*	Golden-rumped Tinker Barbet	iv	1
478	*Prodotiscus regulus*	Sharp-billed Honeyguide	ii	P
527	*Hirundo abyssinica*	Lesser Striped Swallow	iv	3
536	*Psalidoprocne holomelaena*	Black Saw-wing Swallow	ii	2
554	*Parus niger*	Southern Black Tit	ii	1
558	*Anthoscopus caroli*	Grey penduline Tit	ii	1
568	*Pycnonotus tricolor*	Black-eyed Bulbul	iv	1
572	*Andropadus importunes*	Sombre Greenbul	iv	6
576	*Turdus libonyanus*	Kurrichane Thrush	iv	1
589	*Cercomela familiaris*	Familiar Chat	iv	2
599	*Cossypha heuglini*	White-Browed Robin-chat	iv	7
601	*Cossypha caffra*	Cape Robin-chat	iv	5
602	*Cossypha humeralis*	White-throated Robin-chat	iv	5
633	*Acrocephalus palustris*	March-Warbler	iv	Ex
638	*Bardypterus baboecala*	Little Rush-Warbler	ii	10
645	*Apalis thoracica*	Bar-throated Apalis	ii	9
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
651	*Sylvietta refescens*	Long-billed Crombec	ii	1
657	*Camaroptera brachyuran*	Green-backed Camaroptera	ii	7
661	*Sphenoeacus afer*	Cape Grassbird	ii	10
674	*Cisticola erythrops*	Red-faced Cisticola	ii	6
677	*Cisticola tinniens*	Levaillant's Cisticola	ii	10
679	*Cisticola aberrans*	Lazy Cisticola	ii	10
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
691	*Muscicapa caerulescens*	Ashy Flycatcher	iv	3
694	*Melaenornis pammelaina*	Southern Black Flycatcher	iv	3

R No	Scientific names	Common names	Feeding Guild	Nesting Guild
710	*Terpsiphone viridis*	African Paradise-flycatcher	ii	1
713	*Motacilla capensis*	Cape Wagtail	v	2
720	*Anthus lineiventris*	Striped Pipit	ii	8
728	*Macronyx croceus*	Yellow-throated Longclaw	ii	8
732	*Lanius collaris*	Common Fiscal	iv	7
736	*Laniarius ferrugineus*	Southern Boubou	iv	7
743	*Tchagra australis*	Brown-crowned Tchagra	ii	9
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
747	*Telophorus quadricolor*	Gorgeous Bush-Shrike	ii	6
748	*Telophorus sulfureopectus*	Orange-breasted Bush-Shrike	ii	7
753	*Prionops plumatus*	White –crested Helmets-Shrike	ii	1
761	*Cinnyricinclus leucogaster*	Violet-backed Starling	iii	3
787	*Cinnyris talatala*	White-bellied Sunbird	iv	7
791	*Chalcomitra senegalensis*	Scarlet-chested Sunbird	iv	3
792	*Chalcomitra amethystina*	Amethyst Sunbird	iv	3
793	*Hedydipna collaris*	Collared Sunbird	iv	7
796	*Zosterops capensis*	Cape White-eye	iv	7
807	*Amblyospiza albifrons*	Thick-billed Weaver	iv	4
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
811	*Ploceus cucullatus*	Village Weaver	iv	1
816	*Ploceus xanthops*	Golden Weaver	iv	4
828	*Euplectes asillaris*	Fan-tailed Widowbird	iv	9
840	*Lagonosticta rubricata*	African Firefinch	iv	7
846	*Estrilda astrild*	Common Waxbill	iv	9
857	*Lonchura cucullata*	Bronze Mannikin	iv	7
869	*Serinus mozambicus*	Yellow-fronted Canary	iv	7
877	*Serinus sulphuratus*	Brimstone Canary	iv	7
881	*Serinus gularis*	Streaky-headed Canary	iv	7
884	*Emberiza flaviventris*	Golden-breasted Bunting	iv	7

Table 3.6: Bird species found in Community 2 (Relevé 44, 27 – Disturbed riparian open spaces in Nelspruit)

R No	*Scientific names*	Common names	Feeding Guild	Nesting Guild
157	*Accipiter minullus*	Little Sparrowhawk	v	1
158	*Accipiter melanoleucus*	Black Sparrowhawk	v	1
160	*Accipiter tachiro*	African Goshawk	v	1
359	*Turtur tympanistria*	Tambourine Dove	iv	7
361	*Treron calvus*	African Green Pigeon	iii	1
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
386	*Chrysococcyx caprius*	Diderick Cuckoo	ii	8
391	*Centropus burchelli*	Burchell's Coucal	v	9
483	*Campethera abingoni*	Golden-tailed Woodpecker	ii	1
486	*Dendropicos fuscescens*	Cardinal Woodpecker	ii	1
489	*Jynx ruficollis*	Red-throated Wryneck	ii	1
522	*Hirundo smithii*	Wire-tailed Swallow	ii	2
560	*Turdoides jardineii*	Arrow-marked Babbler	iv	7
569	*Phyllastrephus terrestris*	Terrestrial Brownbul	iv	9
599	*Cossypha heuglini*	White-Browed Robin-chat	iv	7
631	*Acrocephalus baeticatus*	African Reed-warbler	ii	4
637	*Chloropeta natalensis*	Black-eyedYellow Warbler	ii	Ex
638	*Bardypterus baboecala*	Little Rush-Warbler	ii	10
657	*Camaroptera brachyuran*	Green-backed Camaroptera	ii	7
732	*Lanius collaris*	Common Fiscal	iv	7
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
751	*Malaconotus blachoti*	Grey-headed Bush-Shrike	v	7
793	*Hedydipna collaris*	Collared Sunbird	iv	7
807	*Amblyospiza albifrons*	Thick-billed Weaver	iv	4
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
811	*Ploceus cucullatus*	Village Weaver	iv	1
813	*Ploceus capensis*	Cape Weaver	iv	3
816	*Ploceus xanthops*	Golden Weaver	iv	4
824	*Euplectes orix*	Southern Red Bishop	iv	4
858	*Lonchura nigriceps*	Red-backed Mannikin	iv	1

Table 3.7: Bird species found in Community 3 (Relevé 27, 28, 41, 42, 52 – Disturbed riparian open spaces in Nelspruit)

R No	Scientific names	Common names	Feeding Guild	Nesting Guild
85	*Ciconia abdimii*	Abdim's Stork	v	Ex
127	*Elanus caeruleus*	Black-shouldered Kite	v	1
355	*Streptopelia senegalensis*	Laughing Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
451	*Upupa africana*	African Hoopoe	v	2
494	*Mirafra africana*	Rufous-naped Lark	iv	5
554	*Parus niger*	Southern Black Tit	ii	1
576	*Turdus libonyanus*	Kurrichane Thrush	iv	1
643	*Phylloscopus trochilus*	Willow Warbler	ii	Ex
645	*Apalis thoracica*	Bar-throated Apalis	ii	9
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
664	*Cisticola juncidis*	Zitting Cisticola	ii	10
674	*Cisticola erythrops*	Red-faced Cisticola	ii	6
678	*Cisticola natalensis*	Croaking Cisticola	ii	10
681	*Cisticola fulvicapilla*	Neddicky	ii	9
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
711	*Motacilla aguimp*	African Pied Wagtail	iv	3
728	*Macronyx croceus*	Yellow-throated Longclaw	ii	8
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
741	*Nilaus afer*	Brubru	ii	1
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
758	*Acridotheres tristis*	Common Myna	iv	2
769	*Onychognathus morio*	Red-winged Starling	iv	2
791	*Chalcomitra senegalensis*	Scarlet-chested Sunbird	iv	3
792	*Chalcomitra amethystina*	Amethyst Sunbird	iv	3
810	*Ploceus ocularis*	Spectacled Weaver	iv	7
816	*Ploceus xanthops*	Golden Weaver	iv	4
824	*Euplectes orix*	Southern Red Bishop	iv	4
831	*Euplectes ardens*	Red-collared Widowbird	iv	9

Table 3.8: Bird species found in Community 5 (Relevé 26, 31, 36, 40, 44, 45 – Vegetation in open spaces on hills in Nelspruit)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
58	*Phalacrocorax africanus*	Reed Cormorant	v	3
94	*Bostrychia hagedash*	Hadeda Ibis	v	3
127	*Elanus caeruleus*	Black-shouldered Kite	v	1
135	*Aguila wahlbergi*	Wahlberg's Eagle	v	1
171	*Falco peregrinus*	Peregrine Falcon	v	2
203	*Numida meleagris*	Helmeted Guineafowl	iv	5
218	*Sarothrura elegans*	Buff-spotted Flufftail	iv	8
352	*Streptopelia semitorquata*	Red-eyed Dove	iv	7
358	*Turtur chalcospilos*	Green-spotted Dove	iv	7
359	*Turtur tympanistria*	Tambourine Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
386	*Chrysococcyx caprius*	Diderick Cuckoo	ii	P
391	*Centropus burchelli*	Burchell's Coucal	v	9
415	*Apus caffer*	White-rumped Swift	ii	2
417	*Apus affinis*	Little Swift	ii	2
421	*Cypsiurus parvus*	African Palm Swift	ii	2
424	*Colius striatus*	Speckled Mousebird	iv	7
426	*Urocolius indicus*	Red-faced Mousebird	iii	7
435	*Halcyon albiventris*	Brown-hooded Kingfisher	v	2
452	*Phoeniculus purpureus*	Red-billed Wood-hoopoe	iv	1
464	*Lybius torquatus*	Black-collared Barbet	iv	1
470	*Pogoniulus chrysoconus*	Yellow-fronted Tinker Barbet	iv	1
471	*Pogoniulus bilineatus*	Golden-rumped Tinker Barbet	iv	1
473	Trachyphonus vaillantii	Crested Barbet	iv	1
474	*Indicator indicator*	Greater Honeyguide	ii	P
478	*Prodotiscus regulus*	Sharp-billed Honeyguide	ii	P
483	*Campethera abingoni*	Golden-tailed Woodpecker	ii	1
486	*Dendropicos fuscescens*	Cardinal Woodpecker	ii	1
527	*Hirundo abyssinica*	Lesser Striped Swallow	iv	3
545	*Oriolus larvatus*	Black-headed Oriole	iv	1
554	*Parus niger*	Southern Black Tit	ii	1
568	*Pycnonotus tricolour*	Black-eyed Bulbul	iv	1
569	*Phyllastrephus terrestris*	Terrestrial Brownbul	iv	6
572	*Andropadus importunes*	Sombre greenbul	iv	6
576	*Turdus libonyanus*	Kurrichane Thrush	iv	1
589	*Cercomela familiaris*	Familiar Chat	iv	2
593	*Thamnolaea cinnamomeiventris*	Mocking cliff-Chat	iv	3
599	*Cossypha heuglini*	White-Browed Robin-chat	iv	7
602	*Cossypha humeralis*	White-throated Robin-chat	iv	5
631	*Acrocephalus baeticatus*	African Reed-warbler	ii	4
633	*Acrocephalus palustris*	March-Warbler	iv	Ex
643	*Phylloscopus trochilus*	Willow Warbler	ii	Ex
645	*Apalis thoracica*	Bar-throated Apalis	ii	9
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
651	*Sylvietta refescens*	Long-billed Crombec	ii	1
657	*Camaroptera brachyuran*	Green-backed Camaroptera	ii	7
661	*Sphenoeacus afer*	Cape grassbird	ii	10
664	*Cisticola juncidis*	Zitting Cisticola	ii	10
674	*Cisticola erythrops*	Red-faced Cisticola	ii	6

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
678	*Cisticola natalensis*	Croaking Cisticola	ii	10
679	*Cisticola aberrans*	Lazy Cisticola	ii	10
681	*Cisticola fulvicapilla*	Neddicky	ii	9
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
691	*Muscicapa caerulescens*	Ashy Flycatcher	iv	3
700	*Batis capensis*	Cape Batis	ii	1
728	*Macronyx croceus*	Yellow-throated Longclaw	ii	8
732	*Lanius collaris*	Common Fiscal	iv	7
736	*Laniarius ferrugineus*	Southern Boubou	iv	7
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
741	*Nilaus afer*	Brubru	ii	1
743	*Tchagra australis*	Brown-crowned Tchagra	iv	9
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
747	*Telophorus quadricolor*	Gorgeous Bush Shrike	ii	6
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
761	*Cinnyricinclus leucogaster*	Violet-backed Starling	iii	3
787	*Cinnyris talatala*	White-bellied Sunbird	iv	7
791	*Chalcomitra senegalensis*	Scarlet-chested Sunbird	iv	3
792	*Chalcomitra amethystine*	Amethyst Sunbird	iv	3
793	*Hedydipna collaris*	Collared Sunbird	iv	7
796	*Zosterops capensis*	Cape White-eye	iv	7
804	*Passer diffuses*	Southern Grey-headed Sparrow	ii	3
805	*Petronia superciliaris*	Yellow-throated Petronia	iv	1
807	*Amblyospiza albifrons*	Thick-billed Weaver	iv	4
810	*Ploceus ocularis*	Spectacled Weaver	iv	10
811	*Ploceus cucullatus*	Village Weaver	iv	1
816	*Ploceus xanthops*	Golden Weaver	iv	4
819	*Anaplectes rubriceps*	Red-headed Weaver	iv	3
824	*Euplectes orix*	Southern Red Bishop	iv	4
828	*Euplectes asillaris*	Fan-tailed Widowbird	iv	9
831	*Euplectes ardens*	Red-collared Widowbird	iv	9
840	*Lagonosticta rubricata*	African Firefinch	iv	7
842	*Lagonosticta Senegal*	Red-billed Firefinch	iv	8
844	*Uraeginthus angolensis*	Blue Waxbill	iv	7
846	*Estrilda astrild*	Common Waxbill	iv	9
857	*Lonchura cucullata*	Bronze Mannikin	iv	7
860	*Vidua macroura*	Pin-tailed Whydah	i	P
864	*Vidua funereal*	Dusky Indigobird	i	P
869	*Serinus mozambicus*	Yellow-fronted Canary	iv	7
881	*Serinus gularis*	Streaky-headed Canary	iv	7
884	*Emberiza flaviventris*	Golden-breasted Bunting	iv	7

Table 3.9: Bird species found in Community 9 (Relevé 32, 33, 34, 35, 38, 46 – Vegetation in open spaces on hills in Nelspruit)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
359	*Turtur tympanistria*	Tambourine Dove	iv	7
371	*Musophaga porphyreolopha*	Purple-crested Turaco	iii	1
435	*Halcyon albiventris*	Brown-hooded Kingfisher	v	2
444	*Merops pusillus*	Little Bee-eater	ii	2
464	*Lybius torquatus*	Black-collared Barbet	iv	1
483	*Campethera abingoni*	Golden-tailed Woodpecker	ii	1
486	*Dendropicos fuscescens*	Cardinal Woodpecker	ii	1
541	*Dicrurus adsimilis*	Fork-tailed Drongo	iv	1
545	*Oriolus larvatus*	Black-headed Oriole	iv	1
554	*Parus niger*	Southern Black Tit	ii	1
569	*Phyllastrephus terrestris*	Terrestrial Brownbul	iv	6
572	*Andropadus importunes*	Sombre greenbul	iv	6
593	*Thamnolaea cinnamomeiventris*	Mocking cliff-Chat	iv	3
602	*Cossypha humeralis*	White-throated Robin-chat	iv	5
643	*Phylloscopus trochilus*	Willow Warbler	ii	Ex
645	*Apalis thoracica*	Bar-throated Apalis	ii	9
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
651	*Sylvietta refescens*	Long-billed Crombec	ii	1
657	*Camaroptera brachyuran*	Green-backed Camaroptera	ii	7
679	*Cisticola aberrans*	Lazy Cisticola	ii	10
681	*Cisticola fulvicapilla*	Neddicky	ii	9
691	*Muscicapa caerulescens*	Ashy Flycatcher	iv	3
694	*Melaenornis pammelaina*	Southern Black Flycatcher	iv	3
701	*Batis molitor*	Chinspot Batis	ii	1
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
747	*Telophorus quadricolor*	Gorgeous Bush Shrike	ii	6
761	*Cinnyricinclus leucogaster*	Violet-backed Starling	iii	3
792	*Chalcomitra amethystine*	Amethyst Sunbird	iv	3
805	*Petronia superciliaris*	Yellow-throated Petronia	iv	1
819	*Anaplectes rubriceps*	Red-headed Weaver	iv	3
840	*Lagonosticta rubricata*	African Firefinch	iv	7
877	*Serinus sulphuratus*	Brimstone Canary	iv	7
881	*Serinus gularis*	Streaky-headed Canary	iv	7
884	*Emberiza flaviventris*	Golden-breasted Bunting	iv	7
886	*Emberiza tahapisi*	Cinnamon-breasted Bunting	iv	5

Table 3.10: Bird species found in Community 10 (Relevé 25, 30, 37, 39 – Open spaces in grasslands in Nelspruit)

R No	Scientific names	Common names	Feeding Guilds	Nesting Guilds
127	*Elanus caeruleus*	Black-shouldered Kite	v	1
135	*Aguila wahlbergi*	Wahlberg's Eagle	v	1
203	*Numida meleagris*	Helmeted Guineafowl	iv	5
473	*Trachyphonus vaillantii*	Crested Barbet	iv	1
554	*Parus niger*	Southern Black Tit	ii	1
631	*Acrocephalus baeticatus*	African Reed-warbler	ii	4
643	*Phylloscopus trochilus*	Willow Warbler	ii	Ex
645	*Apalis thoracica*	Bar-throated Apalis	ii	9
648	*Apalis flavida*	Yellow-breasted Apalis	iv	7
661	*Sphenoeacus afer*	Cape grassbird	ii	10
664	*Cisticola juncidis*	Zitting Cisticola	ii	10
674	*Cisticola erythrops*	Red-faced Cisticola	ii	6
678	*Cisticola natalensis*	Croaking Cisticola	ii	10
681	*Cisticola fulvicapilla*	Neddicky	ii	9
683	*Prinia subflava*	Tawny-flanked Prinia	iv	7
701	*Batis molitor*	Chinspot Batis	ii	1
728	*Macronyx croceus*	Yellow-throated Longclaw	ii	8
732	*Lanius collaris*	Common Fiscal	iv	7
740	*Dryoscopus cubla*	Black-backed Puffback	ii	1
741	*Nilaus afer*	Brubru	ii	1
743	*Tchagra australis*	Brown-crowned Tchagra	ii	9
744	*Tchgra senegalus*	Black-crowned Tchagra	ii	7
748	*Telophorus sulfureopectus*	Orange-breasted Bush Shrike	ii	7
761	*Cinnyricinclus leucogaster*	Violet-backed Starling	iii	3
816	*Ploceus xanthops*	Golden Weaver	iv	4
828	*Euplectes asillaris*	Fan-tailed Widowbird	iv	9
831	*Euplectes ardens*	Red-collared Widowbird	iv	9
877	*Serinus sulphuratus*	Brimstone Canary	iv	7
881	*Serinus gularis*	Streaky-headed Canary	iv	7
886	*Emberiza tahapisi*	Cinnamon-breasted Bunting	iv	5