

CHAPTER 1: INTRODUCTION

1.1 Background

“South Africa has one of the world’s greatest diversity of plants and animal species contained within one country, and is home to many species found nowhere else in the world” (South Africa, 1999). It ranks third among the countries with the highest level of biological diversity in the world, harbouring 7.5% of the world’s recorded vascular plants. This rich biodiversity can be attributed to the broad range of climatic, geological, soil and landscape variations found in South Africa (South Africa, 1999).

South Africa has made a commitment to the conservation and the sustainable use of biodiversity to preserve its wealth of biological life by ratifying the Convention on Biological Diversity (CBD) in 1995. As one of the megadiverse countries in the world (Thuiller et al., 2006), with its biodiversity endangered by population pressure and the development needs of a developing country (South Africa, 2005b), it had to respond by addressing the rapid decline in biological diversity due to habitat destruction and pollution by industrial development. Consequently, biodiversity planning has become a key focus area aimed at the demarcation of priority areas for species and ecosystem conservation (SANBI, 2009) within and outside of formally protected areas.

The identification and monitoring of important components of biological diversity that requires conservation action is a central obligation according to the CBD (Secretariat of the Convention on Biological Diversity, 2000). However, the establishment of protected areas for biodiversity conservation can only be considered successful if human developments are carried out in a sustainable and environmentally sound way. Hence, this international treaty requires governments of signatory countries to develop national biodiversity strategies and action plans, and to integrate these into the broader national policies and plans for development and environment.

Conservation and land-use decisions need a comprehensive inventory of a region’s biodiversity at all levels (species, community, habitat, ecosystem, etc.). The quantification of biodiversity is crucial as it forms the basis for sustainable development activities. Biodiversity relates to sustainable development through the many services and functions it provides for the maintenance of ecosystems and life (Lovejoy, 1995). Thus the National Biodiversity Act (No.

10 of 2004) requires the collation, organization and communication of biological data for sustainable biodiversity management (SANBI, 2009). Such management practices require *inter alia* information on the distribution of plants. Knowledge on the diversity and phytogeography of South Africa's exceptional rich vascular plant flora has been advanced by several researchers including Acocks (1953); Goldblatt (1978); Werger (1978); White (1983); Rutherford & Westfall (1986); Cowling *et al.* (1989, 1997); Low and Rebelo (1996); Steenkamp *et al.* (2005) and Van Wyk & Smith (2001).

Plant distribution data in South Africa is traditionally available on the labels of specimens housed in national, provincial and university herbaria. Distribution data is generally organized at Quarter Degree Grid (QDG) level and stored in a national plant database, called PRECIS (National Herbarium, Pretoria (PRE) Computerized Information System), maintained by the South African National Biodiversity Institute (SANBI). The QDG system was introduced by Edwards & Leistner (1971) as a reference system for citing biological records for Southern Africa at a time before technology provided GPS measurements (Morris & Glen, 1978). Substantial plant distribution data is therefore available for analysis, but the accuracy thereof is 25 x 25 km² (Cowling *et al.*, 1997).

However, the urgent and enormous task of biodiversity assessment for conservation planning requires that we make use of what is available (Colwell & Coddington, 1995). The lack of complete biodiversity data for many parts of southern Africa requires effective and systematic inventory methods such as, for example, the selection of biodiversity surrogates. Along with birds and mammals, vascular plants are the most commonly used surrogates for biodiversity measurement (Reyers, 2001), and are thus also the subject of this study. Vegetation is generally well sampled and accordingly provides good spatial data for biodiversity and conservation planning.

Conservation priority areas are often identified by the quantification of indicator taxa and the subsequent modelling of their spatial distribution, which is the method applied in this study. An attempt is made to use plant indicator taxa to pinpoint conservation hotspots in the western Central Bushveld. These include, amongst others, species diversity, rarity and endemism, as well as useful and alien plants.

The western part of the Central Bushveld Bioregion has been found to be under-represented by conservation studies that provided the main motivation for this work. Until now, floristic

studies of the bioregion have been mainly confined to phyto-sociological surveys (e.g. Van der Meulen, 1978, 1979; Van der Meulen & Westfall, 1979; Winterbach *et al.*, 2000), existing protected areas (e.g. Schulze *et al.*, 1994; Brown *et al.*, 1997; Van Staden & Bredenkamp, 2006), browsing capacity of game or cattle farms (e.g. Friedel, 1988; Peel *et al.*, 1991) or included in local (Reyers, 2004) and countrywide conservation studies (e.g. Edwards, 1974; Reyers *et al.*, 2001; Reyers *et al.*, 2007).

In the past decades, conservation efforts have centered on maintaining biodiversity by shutting out human influences through the establishment of protected areas. Yet long-term conservation of biodiversity features across the landscape depends on preserving hospitable environments and viable populations within natural and managed landscapes (White *et al.*, 1997; Cowling *et al.*, 1999). The increasing loss of biodiversity due to habitat degradation and over-exploitation consequently necessitates data collection on the biodiversity of whole regions in order to address these problems arising from human activities, as well as for “*dealing with the needs of modern nature conservation*” (Jürgens, 1998).

It is of critical importance to identify areas of high conservation value in the landscape matrix. These comprise not only areas of high biodiversity and irreplaceability value, but also of areas with a high current and future vulnerability and threat value (Reyers, 2004). Vulnerability has been defined by Pressey & Taffs (2001) as an estimate of the likelihood of habitat loss or degradation (Reyers, 2004).

The present study is concerned with a detailed landscape scale assessment of plant diversity patterns and distribution to highlight conservation gaps in the under-studied western Central Bushveld Bioregion to inform improvements of the provincial conservation area network. The Central Bushveld Bioregion is one of the spatial terrestrial units defined by Rutherford *et al.* (2006) as intermediate between vegetation type and biome and consisting of a characteristic and unique set of vegetation types.

This approach is necessary as “*reserve systems are central to biodiversity conservation in an era of increasing human environmental impact*” (Kerr, 1997). The basis for a successful nature reserve design and management is dependent on an understanding of the regional biodiversity patterns. Kerr (1997) reasons that reserve selection algorithms do not give useful results for the prioritization of conservation areas without a good, working knowledge of

species distributions, as well as their underlying environmental (e.g. climate, soil, geology) and anthropogenic (e.g. agriculture, mining, urban development) drivers.

In a world that constantly alters landscapes by various landuse changes, coordinated and comprehensive conservation efforts are essential for successful conservation of species and their habitats (Abbit *et al.*, 2000). Yet, only fragments of the biogeography of species in South Africa that need protection are known. All the more it has become crucial to find more comprehensive ways of classifying key areas for species at risk.

There are a wide variety of approaches to identify priority areas for conservation, but most approaches focus on locating sites with large numbers of already imperiled species (Abbit *et al.*, 2000). However, it is equally or even more important to identify centres of biodiversity before they become endangered through anthropogenic developments. Thus, this study aims to make a contribution to locate important floristic areas under imminent threat, defined as important plant areas coinciding with focal points of human development activities. If the quality of land-use and conservation planning can be improved by incorporating a better understanding of the locations of important biodiversity elements and our effects upon them, then the sustainable development of our biosphere may succeed (Davis *et al.*, 1990).

However, the use of plant distribution data on QDG level has some shortcomings (Reyers, 2001). First of all, the incomplete sampling across the grids of a study area results in false records of species presence or absence and thus may cause biased biodiversity estimation. This is also true for the plant diversity of the western Central Bushveld which is insufficiently studied and many QDGs remain under-sampled. The study area falls within semi-arid South Africa, which is generally under-researched as it is of comparatively little economic interest (Jürgens, 1998). The remote rural dominated northern and north-western parts of the western Central Bushveld Bioregion especially are floristically under-sampled.

Secondly, the coarse scale of the QDG system (675 km²) allows only for the establishment of broad plant diversity patterns for conservation planning (Siebert *et al.*, 2001). The present scale of biodiversity data management and the gaps in biodiversity data information need new innovative methods for spatial modelling. This study seeks to make a contribution to find new ways of biodiversity pattern estimation from the extrapolation of incomplete sets of plant species distribution data. The approach to calibrate QDG resolution of spatial data is aimed at more representative mapping of biodiversity patterns. This is a prerequisite for strategic

conservation planning for ‘living landscapes’, capable of ensuring long-term survival and well-being of people and ecosystems (Driver et al., 2003).

1.2 Hypotheses

Hypothesis 1: Floristic data sampled at Quarter Degree Grid level can be extrapolated to estimate plant diversity of under-sampled grids.

Adjacent QDGs are assumed to share a similar flora. Therefore, plant species data can be extrapolated using predefined rules to update plant information of other grids. Extrapolation of plant data can be either based on the presence of similar vegetation patterns or on the assumption that neighbouring grids sharing locally common floristic elements.

Hypothesis 2: Quarter Degree Grid data can be standardized to produce more applicable spatial models.

Updating of under-sampled QDGs is expected to smooth out the imbalance between poorly and well-sampled grids, and thus allows a more realistic spatial modelling of floristic patterns. This can be achieved by the use of standardization profiles.

Hypothesis 3: Floristic patterns of the western Central Bushveld Bioregion can be determined by a specific set of environmental factors at the landscape level.

The presence of floristic patterns in a landscape can be attributed to the fact that floristic diversity is not equally distributed across the landscape, but it rather consists of a continuum between ‘hotspots’ and ‘coldspots’ of plant diversity. This study attempts to identify the environmental variables, or specific sets thereof, that are associated with plant diversity patterns at the landscape level.

1.3 Study approach & design

This study had a two-fold approach, one of acquiring existing plant species data from PRECIS (National Herbarium, Pretoria (PRE) Computerised Information System) maintained by the South African National Biodiversity Institute (SANBI), and another by the extensive collection of plant specimens in two focal areas of the western Central Bushveld, namely the

proposed Heritage Park conservation area and Impala Bafokeng Mining Complex, based on gap analysis.

Complete species lists for each of 50 QDGs comprising the study area had been obtained from various sources, including species localities cited in relevant published and unpublished phyto-sociological studies of the study area.

Existing and sampled plant distribution data has been merged to produce integrative, case specific Excel databases, according to preset criteria for the purpose of data manipulation and analysis. The database has been standardized using predefined rules, a process in which under-sampled grids were strengthened by the extrapolation of species occurrences. Two standardizing profiles have been applied, namely the ‘Centroid Grid’ and ‘integrated degree grid’ profiles, both merging the data of four QDG’s.

1.4 Aims and objectives

The key aim of the study is to test the applicability of extrapolation and standardization of known QDG distribution data of plant species for the purpose of developing more concrete spatial models.

General objectives:

- collect voucher specimens that are representative of the Central Bushveld Bioregion for the purpose of filling the knowledge gap with regard to under-sampled grids;
- assess the floristic diversity and patterns of the western Central Bushveld;
- collate biodiversity data with environmental data to explain floristic patterns;
- quantify important plant species to demarcate important plant areas for the selection of priority areas for conservation;
- assess the floristic and conservation importance of the Heritage Park and the Impala Bafokeng Mining Complex;
- test different methods of extrapolation of species distribution data to standardize QDG data.

1.5 Dissertation outline

Chapter 1 introduces the rationale behind the study and why the western Central Bushveld (WCB) has been selected as the specific study area. The importance of conservation assessment for the WCB is highlighted and how shortcomings of data sampling are addressed in the study.

Chapter 2 gives an overview of the concepts of biodiversity and conservation with focus on South Africa and the western Central Bushveld Bioregion. The biodiversity threats, as well as the value and benefits of biodiversity conservation are discussed.

Chapter 3 provides an introduction to the study area with respect to its location, physical environment, and floristic and vegetational characteristics. Additional information is given about the two focal conservation areas, Heritage Park and Impala Bafokeng Mining Complex.

Chapter 4 outlines the methods used for the modelling of species distribution patterns and the analysis of important conservation hotspots in the western Central Bushveld.

Chapter 5 informs on the results of spatial analyses for conservation planning in the study area.

Chapter 6 discusses the floristic patterns of the western Central Bushveld at different taxonomic levels and how the distribution of plant taxa richness is correlated with environmental factors. A conclusion is given on the success of standardization for improved spatial modelling of species richness in the study area.

Chapter 7 illustrates the priority areas for conservation in the western Central Bushveld. In this context the conservation importance of the proposed Heritage Park and the Impala mining area is discussed.

Chapter 8 gives concluding remarks on the outcomes of the floristic study and recommendations for conservation management. Furthermore, suggestions are made for future studies that will improve the introduced method.

Appendix A and B provides impressions on the studied habitats and flora of the Heritage Park and Impala Platinum mining area respectively. Appendix C lists the voucher specimens

collected during the fieldwork in the focal conservation areas, a) Heritage Park and b) Impala Platinum.