Approaches in the Prioritisation of Areas for Biodiversity Conservation: A Case Study from the Western Cape of South Africa

By

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Declaration

I, Phillippa Kate Southey 212468952, hearby declare that this dissertation for MSc in Zoology is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Phillippa Kate Southey

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Abstract

Historical *ad hoc* allocations of land for biodiversity conservation have led to a biased representation of habitat within the Cape Floristic Region, with Protected Areas concentrated in upland areas at high altitudes and on steep slopes. The field of Conservation Planning developed to ensure that allocations of areas to Protected status no longer result in such bias and rather promotes the persistence of biodiversity. This study reviewed a recent allocation of land to biodiversity conservation within Western Cape of South Africa, using both a quantitative and qualitative approach, to determine their value to biodiversity conservation. The area was previously used for commercial forestry but now has been allocated to conservation land-uses. The allocation was based on the area's value to the forestry industry. The qualitative approach in this study engaged with relevant stakeholder groups to map priority areas, while the quantitative approach used available data on biodiversity features to map priority areas. Neither approach determined that the area allocated is in its full extent a priority for biodiversity conservation. This indicated that in the current era of Conservation Planning, Protected Areas are still being allocated in an *ad hoc* manner, as a result of their limited perceived benefit to anthropocentric needs. The future allocation of land to biodiversity conservation should rather integrate expert knowledge and available quantifiable data to ensure that priority areas for biodiversity conservation are being protected.

Keywords

Spatial Prioritisation, Biodiversity Conservation, Exit Strategy, Conservation Planning

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List of Acronyms

ANOSIM – Analysis of Similarity

ASCII – American Standard Code for Information Interchange

CAPE – Cape Action Plan for People and the Environment

CBA – Critical Biodiversity Area

CFR – Cape Floristic Region

ESA – Ecological Support Area

GIS – Geographical Information Systems

GRI – Garden Route Initiative

GRNP – Garden Route National Park

MDS – Multidimensional Scaling

NFEPA – National Freshwater Ecosystem Priority Areas

NBA – National Biodiversity Assessment

ONA – Other Natural Areas

NNAR – No Natural Areas Remaining

PAP – Protea Atlas Project

SABCA – Southern African Butterfly Conservation Assessment

SAFAP – South African Frog Atlas Project

SAFCOL – South African Forestry Company Limited

SANParks – South African National Parks

SARCA – South African Reptile Conservation Assessment

SIMPER – Similarity Percentages

STEP – Subtropical Thicket Ecosystem Plan

Tif – Tagged Image File

Chapter 1 Introduction

1.1 Prioritisation of Biodiversity Conservation

Protected Area establishment has typically been for reasons other than biodiversity conservation, resulting in Protected Areas networks at a global scale that are biased toward infertile or rugged landscapes, and which are typically not economically valuable for production (Knight & Cowling 2007). Globally the designation of Protected Areas has traditionally been based on scenic beauty, recreational value, historical or cultural significance, or because the land is not in demand for an alternative anthropocentric use (Polasky *et al.* 2008). The result is conservation areas often containing a biased sample of ecosystems and habitats (Rouget *et al.* 2003b; Mackey *et al.* 2008; Joppa & Pfaff 2009). However, for the successful conservation of biodiversity, Protected Areas should contain sufficient habitat on multiple spatial and temporal scales to provide a refuge to all species (Polasky *et al.* 2008). Historical *ad hoc* allocations have resulted in spatial bias, as areas are chosen for reasons other than for their biological significance.

Globally, Protected Areas are biased towards higher elevation, steeper slope, and greater distance from roads and cities (Joppa & Pfaff 2009). South Africa is no exception; the country has an uneven distribution of conservation areas, with only 7.3% of land presently being designated for conservation actions (Department of Environmental Affairs 2012) and 6 out of 9 biomes having less than 50% of their ecosystems represented in Protected Areas (South African National Biodiversity Institute 2013). Uneven distribution of Protected Areas has led to uneven levels of biome protection. The Grassland biome is the most threatened and the least protected, while only 3 of the 9 biomes are considered to be well protected (South African National Biodiversity Institute 2013). At a regional scale, historical land-use pressures for urbanisation and agricultural expansion within the Cape Floristic Region (CFR) have shaped the current conservation area landscape (Cowling *et al.* 2003b). This has resulted in an existing Protected Area bias in relation to climatic and topographic features, with reserves in the CFR being concentrated in upland areas at high altitudes and on steep slopes (Cowling *et al.* 2003b; Rouget *et al.* 2003b).

The field of Systematic Conservation Planning was developed to tackle the biodiversity-bias crisis resulting from the *ad hoc* manner in which Protected Areas had historically been established (Kukkala & Moilanen 2013). Systematic planning is a spatial process of locating, designing, implementing and maintaining areas which are managed to promote the persistence of biodiversity and other natural values (Pressey *et al.* 2007).

Despite recognising the importance of Systematic Conservation Planning (Margules & Pressey 2000) and the commitment of the South African government to develop a national reserve network based on Systematic Conservation Planning principles (Department of Environmental Affairs 2012), in the real world of conservation, there are exceptions to this approach. This study explores the desirability for conservation purposes of a block of land in the CFR that was recently earmarked for conservation (The VECON consortium 2006), but this decision was not based on Systematic Conservation Planning. The approach of this study then is to analyse the conservation value of this area using the tools of Systematic Conservation Planning, and apply hindsight to the validity or otherwise of their decision.

1.1 Systematic Conservation Planning

Early debates around reserve design placed emphasis on size, shape and number of reserves as derived from the theory of Island Biogeography. However, this approach did not offer guidance on how many sites, which sites or which configuration to include in a reserve network (Possingham *et al.* 2000). As early as 1994, the absence of science in the selection and design of Protected Areas was identified (Noss & Cooperrider 1994) and this led to explorations in the use of methods using algorithms or computer programmes to identify sites which would achieve conservation goals (Kingsland 2002). The field of Systematic Conservation Planning emerged from these efforts (Sarkar *et al.* 2006), developing largely in response to a need to provide defensible and objective motivations for the allocation of conservation areas. By the year 2000 the science of reserve design and selection had developed into a systematic approach (Margules & Pressey 2000).

The use of Systematic Conservation Planning approaches involves a number of stages which includes the determination of conservation goals, the identification of and engagement with stakeholders, the collection of socioeconomic and biological data, the selection of biodiversity features and the selection of conservation areas (Sarkar *et al.* 2006). Each stage is aided by the use of planning tools, consisting of software packages implementing a variety of algorithms designed to identify conservation areas for the representation and persistence of biodiversity features (Sarkar *et al.* 2006). Currently, advances in the field of Systematic Conservation Planning have led to an idealised planning process involving 11 stages (Kukkala & Moilanen 2013); (1) delineate the planning area (2) and (3) identify stakeholders and describe their relationship with the planning area (4) identify the goals of the planning process (5) and (6) compile, assess, and refine biodiversity and socio-economic data for the region (7) establish conservation targets (8) review the existing conservation-area network (9) identify the areas for protection (10) implement a conservation plan (11) maintain and monitor (Margules & Sarkar 2007; Kukkala & Moilanen 2013). The goal of Systematic Conservation Planning is to identify areas that should have priority for the allocation of scarce biodiversity-management resources and to separate those areas from factors that threaten the persistence of biodiversity within such areas (Margules & Sarkar 2007).

Systematic Planning is best described as identifying a system of Protected Areas, which conserves as much of a region’s biodiversity features as possible, covering varying spatial scales and hierarchical levels to ensure their persistence (Kukkala & Moilanen 2013). In reality not all biodiversity can be protected; funding and resource shortages determine that only a small amount of it can be protected in the immediate future (Reyers 2004).To ensure that the critical biodiversity is protected the systematic planning process identifies important areas for biodiversity conservation through the process of spatial conservation prioritisation (Kukkala & Moilanen 2013), involving choices about the location of conservation actions and biodiversity management resources. The obvious risk of developing conservation areas without the application of Systematic Conservation Planning is that the resulting Protected Area network may not be the most effective or economical arrangement. Thus, scarce conservation resources and opportunities may be wasted.

1.2 Spatial Conservation Prioritisation

Since its origin, advances in the field of spatial conservation prioritisation have influenced planning processes, the development of policy and the expansion and design of Protected Areas (Wilson *et al.* 2009). Spatial conservation prioritisation is a form of assessment that is aimed to inform decision-making for a particular type of environmental planning problem, it involves choices about the spatial location of actions, where actions refer to any type of land use or management which affects conservation outcomes in the region concerned (Ferrier & Wintle 2009). A choice is required when there is a constraint on the total amount of action allowed or required and therefore, in Protected Area acquisition a choice is required between where to best locate or distribute this action within a region of interest (Ferrier & Wintle 2009). How, given both the effects of humans and the limits on conservation resources, can we know what areas are likely to make the largest possible contribution to biodiversity conservation and hold the greatest assurance for long-term sustainability (Redford & Richter 1999)?

A number of approaches and their associated tools have been developed for conservation prioritisation to ensure that the diversity within species, between species and of ecosystems is protected in a parsimonious fashion. Ferrier & Wintle (2009) identify two distinct approaches to spatial prioritisation. Firstly, there are quantitative approaches which generate priorities from spatial data on the abundance and distribution of relevant biodiversity features using an explicit mathematical or logical algorithm. Secondly, the identification of priority areas can be based on qualitative approaches using expert opinion, where knowledge of individuals that are familiar with biological-ecological patterns and processes within the region of interest is employed (Ferrier & Wintle 2009).

A purely expert-based approach can enable priorities to be identified rapidly in regions where spatial data are coarse, incomplete or unreliable and there is a body of experts for consultation (Ferrier & Wintle 2009). Although local expert knowledge is invaluable, using only expert knowledge makes objective prioritisation difficult due to limitations in an expert's personal experience and knowledge (Lehtomäki *et al.* 2009). In contrast, if suitable data exists or can be generated, then employment of a quantitative approach can enhance the explicitness, repeatability and ultimately the scientific credibility of conservation prioritisation (Ferrier & Wintle 2009). As quantitative methods using mathematical algorithms become more robust, available data on the distribution and abundance of biodiversity features tends to be incomplete and biased in a number of ways (Possingham *et al.* 2000; Grantham *et al.* 2009). This limits their effectiveness at prioritising areas to ensure the persistence of biodiversity features and processes. The two distinctive approaches to spatial prioritisation are outlined in the sections below.

1.2.1 Quantitative Approaches to Spatial Conservation Prioritisation

Spatial conservation prioritisation has developed into a process of undertaking a spatial analysis of available quantitative data to identify locations for conservation action (Wilson *et al.* 2009). A quantitative approach generates priorities from spatial data on relevant biodiversity features such as species distribution, habitat condition or threats. The tool chosen undertakes a mathematical optimisation of the biodiversity features included in the analysis, prioritising areas for conservation in such a way as to find the solution that has the highest possible conservation value.

Conservation planning processes vary markedly in their purpose and extent (Ferrier & Wintle 2009) and will therefore be variable in relation to (1) the nature of the decision to be informed and (2) the goals and constraints to be considered in assessing priority areas. The challenge in undertaking a quantitative conservation prioritisation is identifying the relevant features that need to be considered when assessing priority area options against the prioritisation goals (Ferrier & Wintle 2009).

There has long been a debate on how to allocate priorities for biodiversity conservation; various approaches have been suggested based on threatened ecosystems, remaining natural habitat, protection status, endemism and vulnerability, and irreplaceability (Rouget *et al.* 2003c). Early methods (Faith *et al.* 1996; Faith *et al.* 2001; Faith & Walker 2002) adopted the incorporation of opportunity costs into prioritisation; using a trade-off approach allowing the selection and de-selection of areas in searching for a set which collectively achieve a nominated biodiversity goal, while reducing the threat of alternative land uses. These methods identified sets of biodiversity priority areas that avoided areas of high agricultural and timber production potential, areas of high existing land use intensity, and gave preference to areas of low human population density.

Later research used the level of threat to determine priority areas. Rouget *et al.* (2003c) took a prioritisation approach that advocated for already transformed areas to receive high priority over untransformed areas, because the latter are usually inaccessible or unsuitable and thus out of harm's way, i.e. should they have been suitable for alternative land-uses they would already have been transformed. In contrast Reyers (2004) advocated for prioritisation of untransformed areas that are accessible and have the potential to be used for alternative land-uses. Undertaking irreplaceability and vulnerability assessments are highlighted by Reyers (2004) as a useful way of deciding which areas should receive priority protection. Identifying the relative threats on areas selected for protection was thought to be crucial to combine important biodiversity features and current or future threats when considering priorities (Reyers 2004). The incorporation of information on threatening processes and the relative vulnerability of planning units and features to these processes was also identified by Wilson *et al.* (2009) as crucial for effective conservation prioritisation. Studies of the spatial distribution and temporal manifestation of threats to biodiversity were thought to be essential for strategic conservation planning, as an assessment of vulnerability of an area to threatening processes enables the identification of priorities for conservation action (Rouget *et al.* 2003c).

Methods of spatial prioritisation continue to develop quickly and use varying approaches, however an important consideration are the limitations in their application. A major factor limiting the application of quantitative methods is available data (Rodrigues & Brooks 2007). In many regions data are coarse, incomplete or unreliable and are typically biased towards charismatic species and easily accessible sites (Possingham *et al.* 2000; Rondinini *et al.* 2006; Ferrier & Wintle 2009). Prioritisation is therefore largely based on those surrogates for biodiversity for which data can be obtained, with the assumption that the prioritisations are effective for the conservation of the unknown biodiversity (Rodrigues & Brooks 2007). Even with surrogates, the absence of important undocumented information on biodiversity as well as implementation opportunities and constraints is a disadvantage to quantitative approaches (Cowling *et al.* 2003c).

Computer-based techniques have become the mainstay of area-selection approaches to ensure the selection of areas to promote biodiversity persistence on an objective and justifiable basis (Knight & Cowling 2007). Yet there are historically poor records of implementation of the priority areas identified by existing conservation assessments (Cowling *et al.* 2004). This implementation gap was identified as stemming from the failure of most assessments to focus on and to take active account of implementation issues spanning the complexity of real-world social-ecological systems (Cowling *et al.* 2004; Knight & Cowling 2007). Early on in the development of systematic methods of prioritisation using software in analysis and decision support, a debate began on the need to move away from a purely quantitative approach to prioritisation to allow for the inclusion of social-ecological factors affecting biodiversity conservation. Conservation decisions that ignore natural and anthropogenic dynamics could be ineffective in ensuring the persistence of biodiversity (Pressey *et al.* 2007). In response to Knight & Cowling (2007)'s identification of an implementation gap, Pressey & Bottrill (2008) identify 4 stages in Systematic Conservation Planning which deal with the social, economic and political context for the later technical implementation tasks in conservation planning.

A more recent review of the Systematic Conservation Planning approach identifies that the process of prioritising sites does involve participatory planning (Kukkala & Moilanen 2013). However, in spatial prioritisation, dealing with social and political considerations in particular is difficult in a standardised quantitative manner (Moilanen *et al.* 2009b), as they vary spatially and temporally. In their review of current spatial prioritisation, Moilanen *et al.* (2009b) conclude that there is no analysis method that deals with socio-political considerations. Thus, although planning processes include stakeholder engagement, the quantitative approaches used to spatially prioritise areas as part of the planning process have limited capacity to consider social-political factors. Not accounting for such factors in the planning phase could determine the success of conservation planning (Knight & Cowling 2007).

1.2.2 Qualitative Approaches to Spatial Conservation Prioritisation

The outcomes of systematic conservation assessments are often difficult to implement as they have adopted a purely scientific and biological approach to area prioritisation. These approaches have not accounted for social, economic and political factors that actually determine the success of conservation planning and prioritisation (Knight & Cowling 2007). From the mid-1990s a number of Systematic Conservation Planning projects were undertaken at the sub-regional scale using quantitative approaches to planning. In their assessment of these, Cowling & Pressey (2003) found that few planning studies were followed by effective implementation of conservation action. It was identified by Knight & Cowling (2007) that in the real world, the successful selection and implementation of Protected Areas is the product of a complex collection of factors which are neither biological nor predictable.

Including stakeholders in environmental decisions can improve the success of conservation planning and prioritisation projects. Involving stakeholders is believed by Reed *et al.* (2009) to facilitate a better understanding of the ecosystems and understanding of the human influence on the ecosystem (Reed *et al.* 2009). Through stakeholder participation more comprehensive information inputs on the social, economic and political factors can be considered, which is useful in environmental problems that are complex and dynamic in nature (Reed 2008).

The available quantifiable data for spatial planning is limited, making planning and implementation of Protected Areas particularly challenging. These limitations have necessitated the need for planning to include an investment in compiling the relevant data and involving stakeholder interests (Gleason *et al.* 2010). Including stakeholders will also allow for the inclusion of important undocumented information. Stakeholder engagement has been widely applied, particularly in conservation planning for the marine environment. The inclusion of stakeholders in the planning phase for Marine Protected Areas is motivated by Pomeroy & Douvere (2008), as it is essential in contributing towards the setting of priorities, objectives, and purpose of spatial management plans. Stakeholders are able to identify management challenges associated with implementation as well as management needs and opportunities to consider in the choice of priority areas (Gopnik *et al.* 2012). There is general consensus that marine spatial planning will require engagement with relevant stakeholder groups, with the only debate centring on which stakeholder groups to include in spatial conservation prioritisation (Strager & Rosenberger 2006) and when to include such groups (Human & Davies 2010; Osmond *et al.* 2010; Gopnik *et al.* 2012) in the planning process.

A comprehensive comparison of the planning outcomes of an expert-driven and algorithm-based approach to conservation planning for the CFR was undertaken by Cowling *et al.* (2003c). The use of expert-driven approaches resulted in a prioritisation that was strongly determined by pragmatic considerations; however the prioritisation was influenced by the sample of experts, as well as their individual preferences and knowledge. In contrast; the systematic, quantitative approach excluded important, undocumented information on biodiversity and the opportunities and constraints provided by the stakeholders. Yet the quantitative approach was not constrained by having to consider implementation rationality and socio-economic issues (Cowling *et al.* 2003c). A full list of the advantages and disadvantages of each method discussed by Cowling *et al.* (2003c) is given in Table 1.1.

Table 1.1 Summary of the advantages and disadvantages of expert and algorithm-based approaches to prioritisation. Adapted from Cowling *et al.* (2003c).

Planning approach	Advantage	Disadvantage
Expert-based (Qualitative)	Draws on expert judgement	Bias based on uneven knowledge of regions and taxa
	Includes practical management and implementation issues	Bias based on personal experiences in implementation and management
	Considers socio-economic constraints	
Systematic, algorithm-based (Quantitative)	Explicitly target driven	Not readily comprehensible to managers
	Transparent analysis	Absence of undocumented information
	Uses relatively consistent data	Absence of implementation opportunities and constraints
	Flexible to changes in data and targets	

1.3 Prioritisation within the Study Site

In the CFR , the first reserves were proclaimed for indigenous forest protection in the late 1800s, and despite having more than 20% of the region under some form of protection by the late 1990s, the reserve system was not fully representative of biodiversity patterns or the processes that maintain and generate these (Cowling & Pressey 2003). Similar to those reasons described by Polasky *et al.* (2008) at the global scale, Cowling & Pressey (2003) cite the reason for this being that most reserves were proclaimed in parts of the landscape where the opportunity costs of conservation were low. Reserve selection was biased in favour of rugged, inaccessible and infertile landscapes, and biased against productive and populated lowland areas (Cowling & Pressey 2003).

One fine-scale and two regional-scale systematic conservation plans have been developed within the CFR over the past 13 years to ensure the expansion of Protected Areas within the Region are beneficial to the future conservation of all biodiversity features. The plans undertook to identify spatial priorities requiring conservation action and to create a system of conservation areas using a variety of quantitative and qualitative methods. These plans are discussed in more detail in this section.

1.3.1 Cape Action Plan for People and the Environment

A systematic planning exercise, Cape Action Plan for People and the Environment (CAPE), was undertaken for the entire CFR, a total planning domain of 122 590 km^2, and completed in 2001. The plan aimed to achieve explicit conservation targets for selected features using the decision system C-Plan (Pressey *et al.* 2009). Two principle objectives, representativeness and persistence, were used to determine targets for the following features: land classes, localities of Proteaceae and selected vertebrate species, population sizes for medium-and large-sized mammals, and six different types of spatial surrogates for ecological and evolutionary processes.

Cowling *et al.* (2003b) used a planning approach for the Region that combined data and software with expert judgement. Expert knowledge together with some measures of forage productivity and published space use data, was used in compiling the land classes, the potential densities and spatial requirements of the mammals (Boshoff *et al.* 2001; Kerley *et al.* 2003), and to identify the spatial surrogates for ecological and evolutionary processes (Rouget *et al.* 2003a). The plan accepted the existing reserve system as part of the plan and excluded all areas of land transformed by agriculture and forestry, urbanisation and invasive alien vegetation in the conservation planning analyses (Cowling *et al.* 2003c). The plan was undertaken at a 1:250 000 scale, with planning units within the planning domain being 1/16th degree cells, approximately 400 ha in size.

The result was a system of conservation areas requiring 42%, approximately 40 000 km^2, of the remaining extant habitat in the planning domain. This would, according to Cowling *et al.* (2003b), promote the Region's biodiversity and ensure its persistence and continued diversification within the region.

1.3.2 Subtropical Thicket Ecosystem Plan

A four year comprehensive conservation planning initiative known as the Subtropical Thicket Ecosystem Plan (STEP) was undertaken in the Subtropical Thicket Biome, covering 105 454 km^2 and straddling the Western and Eastern Cape Provinces, and completed in

2003 (Cowling *et al.* 2003a). This project is included here as a planning project for the CFR as the planning domain included a portion of the CFR, within which portion the study area for this MSc is situated.

The STEP plan identified spatial priorities requiring conservation action based on conservation targets set for all biodiversity features used in the study. These features included 169 vegetation types, 3 wetland types, 48 species of large and medium-sized mammals and 5 components of ecological and evolutionary processes (Cowling *et al.* 2003a). The plan was undertaken at a scale of 1:250 000.

Targets were developed for 225 features, and the decision support tool C-Plan (Pressey *et al.* 2009) was used to give each planning unit a value for irreplaceability, indicating the likelihood that the planning unit would be needed as part of conservation network that achieves the targets for all biodiversity features (Cowling *et al.* 2003a).

The first outcome was the identification of mega-conservancy networks comprising conservation corridors covering 21.1% of the planning region (Rouget *et al.* 2006). A second major outcome was a map identifying categories of conservation status within the planning domain to provide spatial priorities for the region (Cowling *et al.* 2003a).

1.3.3 Garden Route Initiative

In 2010 a fine scale systematic plan, the Garden Route Initiative (GRI) was completed with the goal of creating a biodiversity sector plan identifying important biodiversity area networks across three municipal areas within the CFR (Vromans *et al.* 2010).

The planning domain straddled the Western and Eastern Cape and comprised the whole of the George, Knysna and Bitou municipalities, as well as part of the Kouga and Koukamma municipalities (Holness *et al.* 2010). A fine-scale systematic planning process was undertaken to identify categories of priority and the desired management objectives for each municipal area, aimed at providing information on biodiversity for decision making and delineate regional biodiversity priorities (Vromans *et al.* 2010).

The main outcome was a Critical Biodiversity Areas map that identified a network of important biodiversity areas, aimed at linking areas along the coast as well as linking inland mountains to the coast for effective corridors. The landscape within these areas was divided into five categories (1) Protected Areas (2) Critical Biodiversity Areas (3) Ecological Support Areas (4) Other Natural Areas and (5) No Natural Areas Remaining. The sector plans, defined by Vromans *et al.* (2010), sought to support municipalities, government departments, conservation authorities and other planning and environmental professionals in their planning processes by assigning desired management objectives to each landscape category. The Critical Biodiversity Areas map represents a pattern of landscape categories to meet biodiversity targets, in as small an area as possible and in areas with least conflict with other land-uses. For example, the first three categories are identified as biodiversity priority areas which should be maintained in a natural to near natural state, while the last three are not priorities and are targeted for sustainable development (Vromans *et al.* 2010). Biodiversity targets were determined to be areas required for meeting biodiversity patterns and ecological and hydrological processes.

The GRI is the most relevant planning exercise within the study area of my study. The systematic planning process undertaken for the GRI was a target driven assessment using MARXAN planning software (Ball *et al.* 2009) at a scale of 1:10 000, with the planning domain divided into 20 ha planning units (Holness *et al.* 2010). For the assessment process the following input layers were used: (1) vegetation maps (Vlok *et al.* 2008) (2) transformation maps (3) expert-mapped biodiversity features (4) nationally listed threatened ecosystems (5) special habitats that were legislatively protected (6) the distribution of critically endangered, endangered and vulnerable plant species (7) inland aquatic features and (8) marine aquatic features. A detailed vegetation map and a transformation map were new input layers produced for the project, while a variety of existing data sources were used for the other biodiversity features, and ecological processes (Holness *et al.* 2010). The transformation layer broadly indicated how much biodiversity is left and where it is located (Holness *et al.* 2010).

1.4 The Exit Strategy

Currently underway within the CFR is the conversion of land used for commercial forestry purposes to conservation land-uses. In 2008 the South African Government made an in-principle decision that plantations belonging to the South African Forestry Company Limited (SAFCOL) be discontinued for commercial forestry purposes (The VECON consortium 2006).

The decision is to be implemented over a period of twenty years, handing over the land to other designated land-uses upon harvesting of the existing trees. The plantations were seen as marginal for forestry production, with a high business risk for SAFCOL and therefore forestry was deemed to be the incorrect land-use option (De Beer 2012). The decision has become known as the Exit Strategy, and shall be referred to as such for the remainder of this dissertation.

The Exit Strategy was informed by a report (The VECON consortium 2006), commissioned by the then Department of Water Affairs and Forestry; which undertook a broad comparison between the different land-use options for the plantations under consideration. Agriculture and conservation land-use options were compared in terms of their typical water use, number of employment opportunities created, and the typical return on investment. The average rate of return between agriculture, conservation and forestry was used to allocate either an alternative land-use or to retain the commercial forestry practices within those plantations identified for Exit. The Plantations identified were within the Boland and Southern Cape regions of the Western Cape Province.

Informed by The VECON consortium (2006), the Exit of 23 242.5 ha of land managed for commercial forestry, now allocated to be phased over to conservation land-uses, is currently underway in the Southern Cape region of the Western Cape. Of these areas, 21 456.54 ha are allocated for conservation land-uses under the management of South African National Parks (SANParks) (Figure 1.1), within the Garden Route National Park (GRNP). The remainder is to be managed by CapeNature.

The impact of the Exit Strategy on the forestry industry was assessed by The VECON consortium (2006). The assessment determined that as a result of the Exit a net loss of direct employment opportunities would occur and a shortfall in the supply of timber to the industry would result. Socio-economic impacts were assessed by De Beer (2012), particularly within the Southern Cape region. She determined that the communities' dependant on the plantations for their employment would be greatly affected. The impact of the Strategy on conservation was briefly assessed in The VECON consortium (2006) and it was found that the consolidation of sections of the GRNP as a result of the Strategy would contribute to maintaining the ecological integrity of the area.

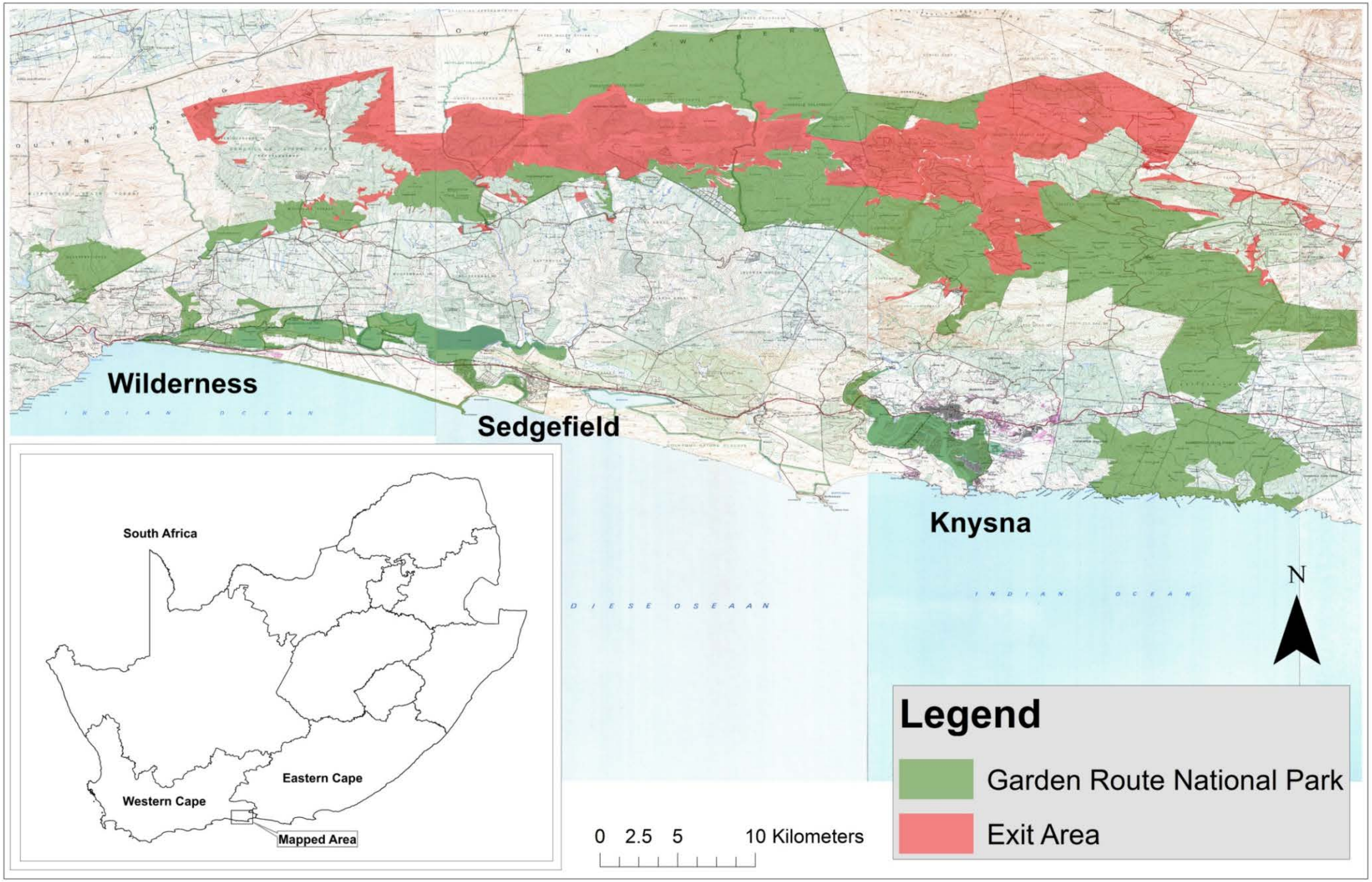

Figure 1.1 A Map of the Exit Area within the Southern Cape region of the Western Cape

Additionally the removal of plantations would increase Mean Annual Runoff, and employment opportunities could be created through invasive plant eradication and fire management. Although potential benefits were briefly considered, the report did identify that the costs of conversion in terms of fire risk, cost of rehabilitation and the management requirements of such conservation areas needed to be considered. The full cost of the conversion to conservation land-uses was not taken into consideration when allocating the areas for conservation; therefore the decision was based largely on the cost-benefit analysis to the forestry industry and not on the cost and benefits to biodiversity conservation.

1.5 Study Rationale

The allocation of land to conservation land-uses in the Exit Strategy was not identified through Systematic Conservation Planning, and it is largely a result of opportunity cost of agriculture and forestry land-uses being considered too low (The VECON consortium 2006; De Beer 2012). Although the allocation of the Exit Areas for conservation land-uses was not systematic, an increase in land for conservation in the Southern Cape could contribute to the ecological integrity of the region (The VECON consortium 2006). It also inadvertently allocated areas for conservation in line with past recommendations by Rouget *et al.* (2003a), who recommended prioritisation based on the principle of choosing already transformed areas over untransformed areas. The need for Protected Area expansion has been identified in the National Protected Area Expansion Strategy for South Africa (Government of South Africa 2010) and these exit areas do contribute to achieving the targets for the SANParks expansion strategy (South African National Parks 2008; Castley *et al.* 2009). The National Protected Area Expansion Strategy identified a need to grow the land-based Protected Area network within South Africa to support the persistence of biodiversity and ensure the provision of ecosystem goods and services into the long term (Government of South Africa 2010).

Protected Area location bias within the CFR has seriously constrained representation of biodiversity pattern and process due to limited protection of lowland areas and macro-climatic gradients (Rouget *et al.* 2003b). In addition, habitat diversity is poorly represented. These existing constraints on biodiversity pattern and process representation in Protected Areas, require the careful prioritisation of future Protected Area. The variation in approaches to prioritisation to reach National Expansion targets, leading to a variation in outcomes, poses an additional challenge when deciding on how best to conserve biodiversity conservation. Prioritisation methods vary in their requirements for prioritisation, and such variation will have implications for the design and allocation of priority areas. Considering the need for careful prioritisation, it is important to understand if the allocation of land to conservation land-use has significant differences between the varying methodologies.

Sarkar *et al.* (2006) define prioritisation as the scaled measure of conservation value of a site. The decision to Exit was based largely on a commercial forestry cost-benefit analysis, which inadvertently prioritised areas for biodiversity conservation. This prioritised areas for conservation based on their lack of value to the forestry industry. In contrast to the methods used for prioritising the conversion of land-uses from commercial forestry to conservation, this MSc aims to use the conversion process in the Southern Cape to provide a comparison of two differing prioritisation techniques. By undertaking stakeholder-based and quantitative approaches to identify priority areas out of those identified for exit; one can objectively compare the differences between prioritisation approaches, and asses the value of the Exit Strategy area to conservation.

Although there have been previous biodiversity planning projects within the region, most have been undertaken at a broad scale or have not included the Exit Areas in their priority assessments. Both the CAPE and the GRI studies identified plantations within the landscape as transformed, thus excluding them in much of the prioritisation. In addition, the GRI planning process included a cost layer to drive selection of planning units away from transformed, degraded, alien-infested or fragmented areas. The Critical Biodiversity Areas Map strongly favour natural sites above degraded sites, and avoids heavily alien infested sites and transformed areas (Holness *et al.* 2010). The GRI placed transformed areas as No Natural Areas Remaining category and recommended that the area be managed for development. Of the total 21 456.54 ha being handed over to SANParks, the GRI prioritised 8 470.25 ha of that area in the Critical Biodiversity Areas map as important for biodiversity conservation. The remaining 12 986.29 ha were indicated as transformed and according to the GRI are more suitable for development. This study will allow for a review of the potential value of the remaining areas to biodiversity conservation. This study aimed to undertake an objective, fine-scale assessment of the Exit Areas, using two alternative methods, based on their value for biodiversity conservation.

The study has been undertaken using two different methodologies of determining priority areas for biodiversity conservation, a qualitative approach using a stakeholder engagement process and a quantitative approach using a prioritisation software programme. Each methodology has been applied to a prioritisation of the Exit Areas to be incorporated into the GRNP, and is discussed further in the ensuing chapters.

1.6 Aims and Objectives

This MSc aimed to investigate if the allocation of land to conservation land-use has significant differences between varying methodologies, using the conversion process in the Southern Cape to provide a comparison of two differing prioritisation techniques.

This study had two main objectives. The first objective was to undertake a fine-scale assessment of the value of the Exit Areas to conservation using the tools of Systematic Conservation Planning. The second objective was to assess the value of the Exit Areas using alternative methods to provide a comparison of the prioritisation outcomes between each approach.

The study has been undertaken using two different methodologies of determining priority areas for biodiversity conservation, a qualitative approach using a stakeholder engagement process and a quantitative approach using a prioritisation software programme. Each methodology has been applied to a prioritisation of the Exit Areas to be incorporated into the GRNP, and is discussed further in the ensuing chapters.

Chapter 2 Determining Priority Areas for Biodiversity Conservation Using a Quantitative Approach

2.1 Introduction

Using quantitative, computer-based techniques has become a standard approach to the prioritisation of areas for biodiversity conservation. Such methods are effective at achieving plans for the representation of vulnerable areas and species, as well as biodiversity pattern and process (Cowling *et al.* 2003c; Kremen *et al.* 2008). Yet restrictions to such methods have also been identified, attributed largely to limitations with available data (Possingham *et al.* 2000; Rondinini *et al.* 2006). This study aimed to determine priority areas for biodiversity conservation using a quantitative and qualitative method for comparison. Here I present the quantitative approach, and its outcomes.

There are a number of software-based packages for conservation planning and spatial prioritisation that allow systematic, quantitative approaches, using spatially-explicit data on biodiversity features (Moilanen *et al.* 2009d). A first step in this study was therefore to compare different packages, in order to identify the most appropriate tool. Readily available datasets on various biodiversity features were used in this study to produce a prioritisation of the Exit Area for comparison against the original decision and the qualitative approach described in Chapter 3.

The nature of the original allocation (The VECON consortium 2006) of the Exit Areas (i.e. areas previously allocated to commercial forestry, but now allocated to conservation) was based on their value to the forestry industry. This leads to the hypothesis that not all areas designated for Exit would be determined to be priority areas for biodiversity conservation. This may be tested by determining the value for biodiversity conservation. This chapter aimed to systematically prioritise the Exit Areas using available biodiversity features data. Although previous Systematic Conservation Planning projects have been undertaken within the region of study (Cowling *et al.* 2003a; Cowling *et al.* 2003b; Vromans *et al.* 2010), these were either at a very broad scale or excluded commercial plantations from their planning process. Excluding areas under commercial plantations did not allow for an assessment of their value to biodiversity conservation. Those projects undertaken at a broader scale, which included the commercial plantation areas, did not undertake a detailed assessment of these areas, and broadly categorised areas in terms of their priority for biodiversity conservation. My study would allow for a detailed assessment of areas, previously either un-assessed or broadly defined.

2.2 Study Area

The study was conducted within the Southern Cape region of the Western Cape Province of South Africa (Figure 2.1). The study area is restricted to the Wilderness and Knysna sections of the Garden Route National Park (GRNP) and those Exit Areas, which at the time of commencing with the study in June 2013, had been allocated to South African National Parks (SANParks) for incorporation into those sections of the Park (33°58'S 23°14'E - 33°56'S 22°30'E) (See Figure 1.1 in Chapter 1). This is a total study area of 61 283.44 ha, incorporating 21 456.54 ha allocated for Exit and 39 826.9 ha of the GRNP.

The study area forms part of the Cape Fold Belt, extending along the southern slopes of the Outeniqua Mountains, east of the Touw River and west of the Keurbooms River, and is characterised by rugged mountains, foothills and coastal plains (Baard & Kraaij 2014). The geology of the area largely consists of Table Mountain Sandstone (Seydack *et al.* 2011). Mean annual rainfall ranges between 700 – 1230 mm, occurring in all seasons. There is a rainfall gradient, increasing from west to east and rainfall is also subject to topographic influences (Seydack *et al.* 2011). The study area falls within the three municipal areas of George, Bitou and Knysna, incorporating the towns of Sedgefield, Knysna, George and Wilderness. One of the most significant land-uses within the region in terms of extent and socio-economic impact is commercial forestry (De Beer 2012; Baard & Kraaij 2014). The areas affected by the Exit Strategy are located within rural and economically depressed regions, characterised by high unemployment and poverty (De Beer 2012). The local economies of George and Knysna have a close relationship to the forestry industry, particularly in the Knysna Municipal Area where forestry and its downstream activities represent a sizeable portion of the agricultural and manufacturing sectors (The VECON consortium 2006).

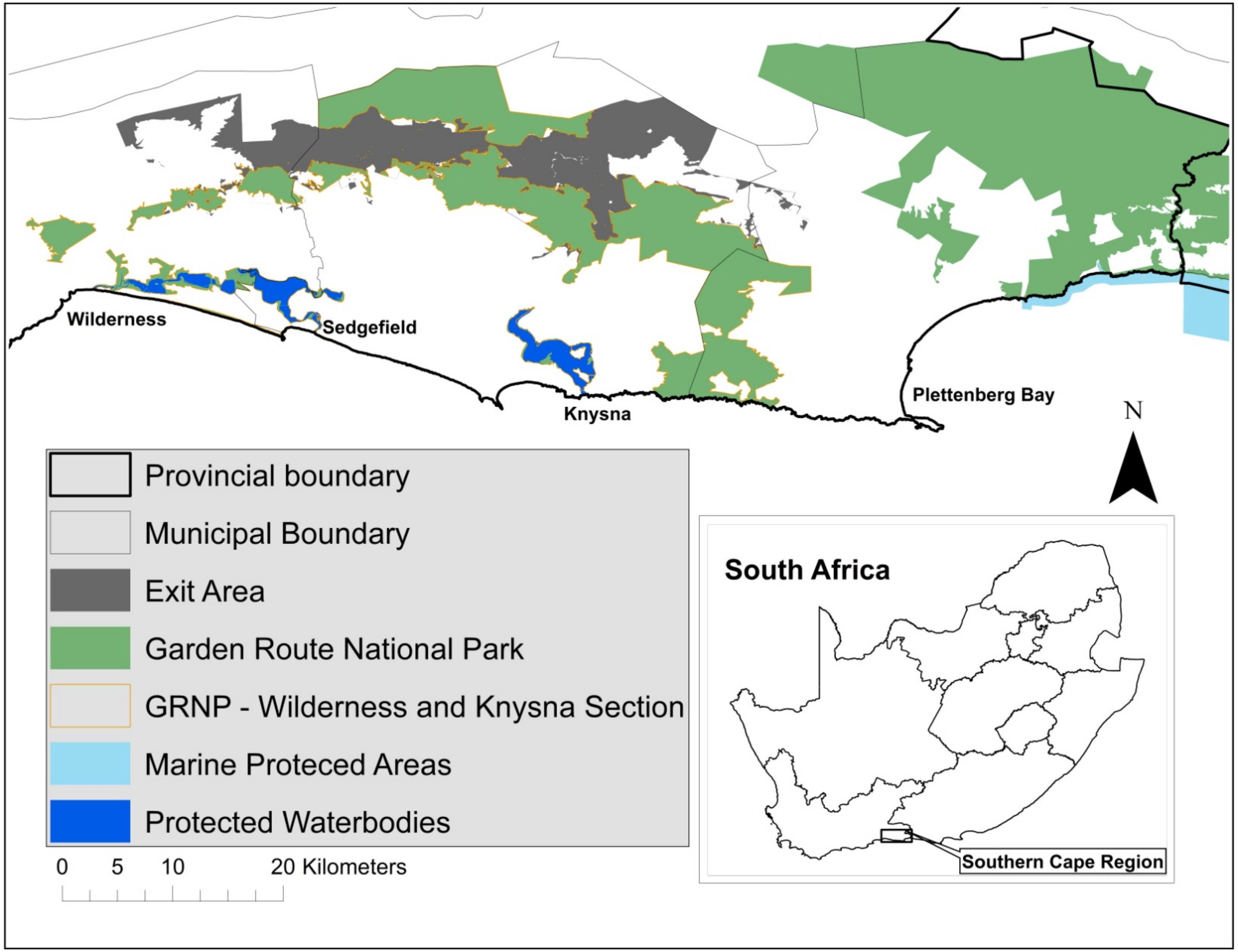

Figure 2.1 Map of the Study Area, indicating the location within South Africa and the Exit Areas (grey shaded) in relation to the Garden Route National Park and local towns.

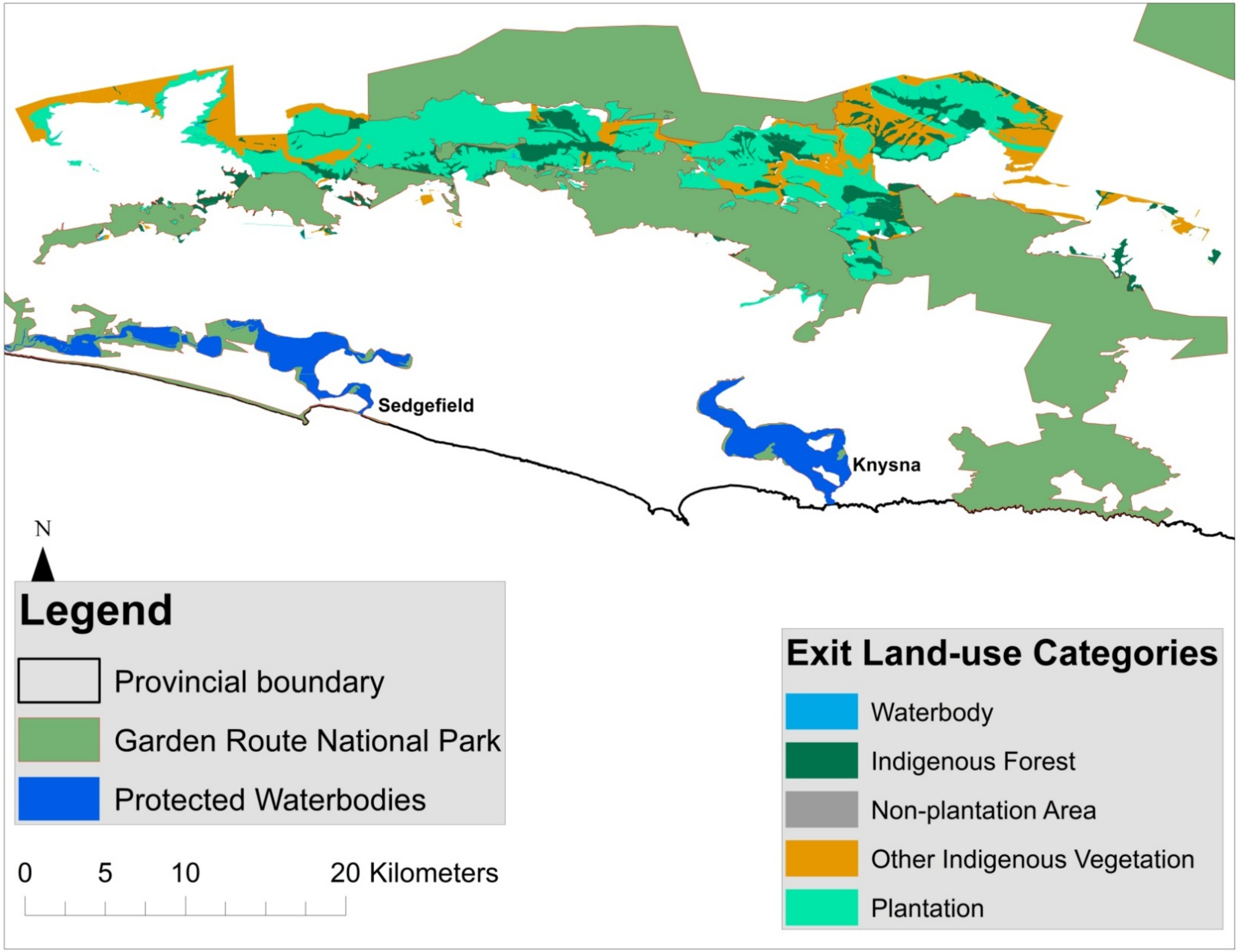

Figure 2.2 Map of the current land use within the Study Area, showing the Garden Route National Park and the detail within the Exit Areas.

The GRNP is a highly fragmented Protected Area, consisting of detached portions arranged in varying configurations with agriculture, forestry and towns dispersed along its boundaries (Baard & Kraaij 2014). Terrestrial vegetation within the park comprises fynbos shrublands and Southern Afrotemperate Forests, smaller areas of Cape Estuarine Salt Marshes and seashore vegetation are associated with the estuarine habitats within the GRNP (Mucina & Rutherford 2006; Baard & Kraaij 2014).

The Exit Areas include 9 199.438 ha of commercial plantations of *Pinus* species managed by Cape Pine Investment Holdings Ltd (De Beer 2012). The plantations, their associated road and firebreak network, are leased from the South African Government by Cape Pine Investment Holdings Ltd. Included in the lease is the management of all water bodies and other non-plantation areas within the Exit Area. Non-plantation areas are quarries, burial sites, buildings and pastures. Also included in the Exit Strategy (Figure 2.2) are patches of indigenous Southern Afrotemperate forest and other indigenous vegetation, the type of which is unspecified. The non-plantation areas and patches of indigenous vegetation compose the remaining 12 257.102 ha of the Exit Area.

2.3 Methods

2.3.1 Selection of the Analytical Tool

Quantitative approaches to spatial conservation prioritisation generate priorities from mapped data on relevant biodiversity features (e.g. species distributions and habitat types) using a mathematical algorithm (Ferrier & Wintle 2009) (See Chapter 1). Traditionally, prioritisation tools have used an approach that determines the optimal (as reflected for the goals of the planning exercise) location and suggests the layout of Protected Areas. This study did not require a complete reserve network design solution, but rather an indication of the relative priority of the Exit Areas. For this reason, tools were sought which did not only offer a reserve design solution. Two conservation planning software packages were recommended for the study based on their outputs, Zonation (Moilanen *et al.* 2012) and Polyscape (Jackson *et al.* 2013). The suitability of these two packages for use in this study were reviewed together with a more traditional and widely applied Systematic Conservation Planning package, Marxan (Ball *et al.* 2009).

A set of criteria was developed to assess the suitability of the three software packages for this study. These criteria were adapted from those recommended by Regan *et al.* (2009) for use when evaluating conservation planning tools. The specific requirements from a tool for application in this study (Table 2.1) were based on the required outcomes and the available data for the study. Each tool was assessed by examining the requirements and capacity of each software package against the specific project requirements, using a review of prioritisation tools undertaken by Moilanen *et al.* (2009d) as well as by reviewing previous studies which have used the software.

Although Marxan has been widely applied in conservation planning, including previous applications within the planning domain (Vromans *et al.* 2010), the outputs of Marxan do not align with those required for the project. Marxan aims to minimize the combination of the cost of the Protected Area network and the boundary length of the entire Protected Area system; whilst at the same time meeting a set of biodiversity targets (Ball *et al.* 2009). The purpose of this study was not to find a best design for a Protected Area network but rather to review site prioritisation. In addition, Marxan is explicitly target based, and many of the biodiversity features used in this study do not have clear conservation targets. For these reasons it was not selected. The Polyscape tool is a new package available for conservation planning, and minimal literature was found on its application. Even though information on the tool was limited, Polyscape was found to be unsuitable due to the output of the software being incompatible (Table 2.2) with the aims of the study. Polyscape formulates a Land Impact Map based on the proposed activities and does not assess biodiversity conservation value.

Zonation was selected above Marxan due to the desired outputs of the study being in line with the outputs of the software, as well as the data input requirements of the software being compatible with the data available for the study. In contrast to Marxan, Zonation produces a priority ranking of the study area, rather than satisfying feature-specific targets with a minimum cost (Moilanen *et al.* 2011). Zonation develops a priority ranking of the entire landscape (Lehtomäki & Moilanen 2013) which was expected to allow for easier comparison between the outputs of the qualitative approaches (Chapter 3). The intention of the tool is the analysis of biological data, with the aim to identify a spatial solution that provides good conservation outcomes (Moilanen *et al.* 2009a). The software uses a raster cell for each biodiversity feature included in the analysis, and each cell contains a feature-specific weight. It starts from the assumption that the best conservation solution would be to protect everything (Lehtomäki & Moilanen 2013). It then proceeds to rank cells by way of iterative removal of the least important remaining cell, always removing the cell that leads to the smallest loss of conservation value (Lehtomäki *et al.* 2009; Di Minin *et al.* 2014). Accounting for the total and remaining distribution of biodiversity features, weights given to features and feature-specific connectivity (Di Minin & Moilanen 2014). The order of removal of cell starts from the full landscape and discards those of lowest value from the edge of the remaining area, thus maintaining a degree of structural connectivity (Moilanen *et al.* 2005). The order of cell removal then determines the priority ranking, those removed first are lower priorities than those removed last.

Table 2.1 **Evaluation criterion for quantitative tools, developed from Regan *et al.* (2009). The specific requirements of this study for each Evaluation Criteria are listed in the second column.**

Evaluation Criteria	Project requirements
1. Data inputs and format requirements	The ability to accept binary data was required
2. Time required for data preparation and analysis	Data preparation required to be completed within 6 months
3. Capacity to use surrogate data in analysis	Available data for the study was required to be used as surrogates for all biodiversity features
4. Specific scale requirements	Prioritisation was to be undertaken at a regional scale i.e. a scale of less than 1:10 000
5. Treatment of uncertainty	Ability to account for uncertainty in the data was required
6. Software outputs	A prioritisation ranking of the study area

Table 2.2 Summary table of the spatial prioritisation tools assessed. Tools were evaluated against each criteria listed in Table 2.1, criteria successfully fulfilled are indicated by a tick and those not are marked with a cross.

Criterion		**Tool**	
	Marxan	**Zonation**	**Polyscape**
1 –Data inputs	✓ Operates on polygon vector data, all input data must be classified into presence-absence (Di Minin *et al.* 2014)	✓ Operates on raster data, binary data accepted (Thomson *et al.* 2009; Di Minin *et al.* 2014)	× Raster data in a Digital Elevation Model (Jackson *et al.* 2013)
2 – Time requirements	✓ Quick (Regan *et al.* 2009)	✓ Analysis is quick (Di Minin *et al.* 2014).	× Unknown
3 – Surrogate capacity	✓ Yes	✓ Yes. By using the Additive Benefit Function rule, surrogate data can be included	× No capacity identified
4 - Scale	✓ Has been applied at regional, national and continental scale (Ball *et al.* 2009; Vromans *et al.* 2010)	✓ Has been applied at regional and national scale (Kremen *et al.* 2008; Lehtomäki *et al.* 2009)	× Designed to work with national scale datasets (Jackson *et al.* 2013)
5 - Uncertainty	× There is no mechanism for directly including natural variation in parameters (Regan *et al.* 2009)	✓ Includes explicit uncertainty analysis as part of the software (Regan *et al.* 2009)	× Does not explore uncertainty in analysis (Jackson *et al.* 2013)
6 - Outputs	× Best set of reserve systems (Regan *et al.* 2009)	✓ Ranked prioritisation of the landscape (Lehtomäki *et al.* 2009)	× Land management impact map (Jackson *et al.* 2013)

2.3.2 Data Set Identification and Collection

A review of four biodiversity planning projects and seven Atlas projects was undertaken, in the search for suitable data on biodiversity features to use in the analysis (Table 2.3). Datasets on numerous biodiversity features was collected from seven of these projects, together with the necessary boundary information for the GRNP and Exit Areas, and prepared in the ArcGIS 10.1 Geographic Information Systems (GIS) package for inclusion in the analysis. Observation data for four taxonomic groups were obtained from Atlas projects, together with vegetation data and priority area data from biodiversity planning projects (Table 2.4).

Due to limitations in data availability, a subset of the datasets investigated (Table 2.3) was used in this study. The point locality data on birds and threatened plant species was requested from the South African Bird Atlas Project and the Custodian of Rare and Endangered Wildflowers, respectively, but these datasets were unavailable upon request. Point locality data for African Mammal species was also requested from The Mammal Map project; however locality data are currently embargoed. Both National Biodiversity Assessment (NBA) datasets on freshwater and terrestrial ecosystem priority areas were excluded. The NBA Terrestrial Ecosystem dataset was excluded as finer scale assessments were preferred, where possible, for use in the study. The finer scale terrestrial ecosystem priority mapping undertaken in the GRI (Vlok *et al.* 2008) was used in this study. The NBA Freshwater Ecosystems dataset was informed by the National Freshwater Ecosystem Priority Area (NFEPA) Project. Thus the NBA freshwater data was excluded as the NFEPA data was used in the study. The NFEPA data included five layers, of which only the River Freshwater Ecosystem Priority Areas layer was included in the study. Two of the NFEPA layers, the NFEPA Wetlands and NFEPA Rivers, were excluded to avoid duplication as they are included as Critical Biodiversity and Ecological Support Area layers in the GRI dataset. The remaining layers prioritised catchments based on the occurrence of threatened fish species; the River Freshwater Ecosystem Priority Areas layer was used as its inclusion of river condition together with the occurrence of threatened species provided a more comprehensive assessment of priority.

The point locality data sets received for the Southern African Butterfly Conservation Assessment (SABCA), South African Frog Atlas (SAFAP), South African Reptile Conservation Assessment (SARCA) and Protea Atlas (PAP) projects were provided per Quarter Degree Grid Square for the study area. Observations were excluded if the species data were incomplete. The observations for a species from the SARCA dataset, as well as a species from the PAP datasets were excluded from the study as neither species was described correctly, a genus was provided but no species name. For all datasets, multiple observations of a species over time and at the same point were included as one observation in the analysis.

Table 2.3 All projects and the associated spatial biodiversity data investigated for incorporation into this study.

Project	Source	Data available
Custodians of Rare and Endangered Wildflowers	South African National Biodiversity Institute	Point locality data for South Africa’s threatened plants
Garden Route Initiative	South African National Parks	Spatial priorities for biodiversity conservation
Mammal Map	University of Cape Town	Distribution records for all African mammal species
National Fresh Water Ecosystem Priority Areas in South Africa	Water Research Commission	Spatial priorities for South Africa’s freshwater ecosystems
National Biodiversity Assessment Terrestrial Ecosystem Threat Status	South African National Biodiversity Institute	Spatial priorities for terrestrial ecosystems within South Africa
National Biodiversity Assessment Freshwater Ecosystems	South African National Biodiversity Institute	Spatial priorities for river and wetland ecosystems within South Africa
Protea Atlas Project	South African National Biodiversity Institute	Point locality data for Proteaceae species throughout South Africa
Southern African Butterfly Conservation Assessment	University of Cape Town	Point locality data for butterfly species throughout South Africa
South African Frog Atlas Project	University of Cape Town	Point locality data for frog species throughout South Africa
South African Reptile Conservation Assessment	University of Cape Town	Point locality data for reptile species throughout South Africa
South African Bird Atlas Project	University of Cape Town	Point locality data for bird species throughout South Africa
Subtropical Thicket Ecosystem Project	South African National Biodiversity Institute	Spatial priorities for biodiversity conservation

Table 2.4 Spatial biodiversity datasets used in the quantitative analysis. The second column describes the format of spatial data received and its scale. A basic description of the dataset is also given.

Data set	Data Type and Description	Age of data
National Fresh Water Ecosystem Priority Areas in South Africa	Vector, Polygon and Line data of rivers, wetlands and catchment areas. Freshwater Ecosystem Priority Areas were identified at the sub-quaternary catchment scale for the categories: Rivers, Wetlands and Fish Sanctuaries (Nel *et al.* 2011). Mapped at a scale of 1:500 000.	Completed in 2011
Garden Route National Park boundaries	Vector data of the current layout of the Garden Route National Park.	Boundary data from 2013
Exit Strategy boundaries	Vector data of the current layout of all areas to be exited to SANParks for incorporation into the Wilderness and Knysna Sections of the GRNP.	Boundary data from 2013
Garden Route Initiative: Critical Biodiversity Areas Map	Landscape is divided into 5 categories based on critical biodiversity features, and desired management objectives for each category are provided (Holness *et al.* 2010; Vromans *et al.* 2010). Landscape categories are Vector data. Mapped a scale of 1:10 000.	Completed in 2010
Garden Route Initiative: Vegetation Map	Vector data of vegetation types. Vegetation was mapped as untransformed units, as it was predicted to be before European settlement and mapped at a scale of 1:50 000 (Vlok *et al.* 2008).	Completed in 2008
Protea Atlas Project	Point locality data, presence only. Dataset includes distributional data of Southern African protea species, and provides a national conservation status for each species.	Observation data from 1991 to 2004
Southern African Butterfly Conservation Assessment	Point locality data of butterfly species, presence only. A Database of species distribution records, including their global conservation status (Mecenero *et al.* 2013).	Observation data from 1983 to 2012
South African Frog Atlas Project	Point locality data for frog species, presence only. An assessment of regional hotspots for frogs, including a map of the distributions of all species and an assessment of the global conservation status of each (Minter *et al.* 2004).	Observation data from 1969 to 2011
South African Reptile Conservation Assessment	Point locality data for reptile species, presence only. A National database of species distribution, together with a national conservation status of each species (Bates *et al.* 2014).	Observation data from 1910 to 2012
Subtropical Thicket Ecosystem Project	Vector data. Spatial priorities are identified that require conservation action based on the conservation targets set for all biodiversity features used in the study. Mapped at a scale of 1:250 000 (Cowling *et al.* 2003a).	Completed in 2003

2.3.3 Data Preparation

Running the quantitative analysis in Zonation (Moilanen *et al.* 2009a; Moilanen *et al.* 2009c) required two steps of data preparation. Firstly, as Zonation operates on raster data, all vector and point data was pre-processed to raster data. Zonation generates a ranked prioritisation of the landscape by accounting for weights given to biodiversity (Lehtomäki *et al.* 2009), thus the second step was to assign a weight to all biodiversity features based on their status. All GIS work was undertaken in ArcGIS version 10.1.

In the raster conversion process, ArcGIS recommends a Default Cell Size based on the smallest possible cell size for the data being converted. The Default Cell Size recommended for each dataset was averaged to determine the cell size to be used for this study. A cell size of 200 x 200 m was determined. This cell size ensured a greater resolution of the study area, reducing any edge effects that may arise as a result of the conversion process. All point and vector data was clipped to within the study area boundaries and converted. The raster files were exported as Tagged Image File (tif) or American Standard Code for Information Interchange (ASCII) files for input into Zonation. The GRI dataset also includes a vegetation layer, of which one vegetation type, Dune Sandplain Fynbos, and one aquatic habitat type, Outeniqua Perennial Stream, was excluded due to the chosen resolution being too low for the size of their polygons.

There was variation in scale of the threatened status of species (i.e. some statuses were according to a national scale and other a global scale). Such variation was also found in the priority rankings used in the NFEPA, GRI and STEP projects, prioritisation categories varied between three and five for different projects. This necessitated the development of an independent, scaled ranking for use in analysis (Di Minin *et al.* 2013; Di Minin & Moilanen 2014). A scale of 1 to 4 was used to weight all biodiversity features, with 4 being Highly Threatened, 3 Moderately Threatened, 2 Vulnerable and 1 Not Threatened. For the SABCA, SAFAP, SARCA and PAP features, weights were assigned to species based on the global or national conservation status provided. Those species with a high conservation status were considered higher priority than those not threatened, and were weighted accordingly (Table 2.5). All species which were not provided with a status were assigned a status Unknown and weighted as Vulnerable.

All other datasets (STEP, GRI and NFEPA) ranked the landscape in terms of their importance for maintaining ecological process' or biodiversity feature/s. For the Zonation weighting, the areas important for maintaining biodiversity features and ecological processes were considered higher priorities than those not necessary for maintaining features/processes. The STEP dataset already used a four scale ranking, thus these were just converted to the respective weighting categories (Table 2.5)

The GRI dataset included landscape categories and assigned desired management objectives for each, the Zonation weighting of each landscape category was based on the management objectives. The landscape categories of Critical Biodiversity Areas (CBA) and Ecological Support Areas (ESA) have a desired management objective of maintaining the natural state (Vromans *et al.* 2010), and were weighted as Highly and Moderately Threatened, respectively. Other Natural Areas (ONA) and No Natural Areas Remaining (NNAR) are not priority landscape categories and their management objectives are for sustainable development (Holness *et al.* 2010). ONA's are areas of natural vegetation not identified as a CBA or ESA, while NNAR are those that allegedly no longer contribute to the biodiversity of the area and include plantations and agriculture (Holness *et al.* 2010). These landscape categories were not desirable for conservation land-uses and are preferred for the development of other land-uses, making them vulnerable to the loss of any remnant natural areas and those areas with the potential to be beneficial for biodiversity conservation. The allocation of the areas to land-uses other than conservation could lead to the loss of existing natural areas as well as potential natural areas. For this reason both ONA and NNAR are weighted as Vulnerable.

The NFEPA River Freshwater Ecosystem Priority Areas layer rated catchments according to river condition and their value for rehabilitation of threatened fish species (Nel *et al.* 2011). The Zonation weighting for features in this layer was based on their coded river condition. Catchments coded with 1 are in good condition, and were weighted as Highly Threatened. Catchments coded as 2 are not in good condition but identified as habitat for threatened fish species. A code of 3 is a catchment containing a set of rivers with the potential to rehabilitate to a good condition. Catchments with both 2 and 3 coding were weighted Highly Threatened due to the level of threat and the potential value of such catchments. Codes of 4 are upstream areas requiring management to prevent downstream degradation. Because

4 coded catchments gave no indication of river condition they were weighted as Vulnerable as there was a potential for degradation and associated downstream effects. A summary of all datasets, their status/categories and their weighting is provided in Table 2.5.

Table 2.5 The weighting of features used in the Zonation analysis. The original category/status provided with each dataset is listed against the weighting assigned for analysis.

Dataset	Source of Information	Original Categories	Weighting for Analysis
NFEPA: River Freshwater Ecosystem Priority Areas	Provided with dataset	1, 2 and 3	Highly threatened
		4	Vulnerable
Garden Route Initiative: Priority Areas	Provided with dataset	Protected Areas	Not threatened
		Critical Biodiversity Areas	Highly threatened
		Ecological Support Areas	Moderately threatened
		Other Natural Areas	Vulnerable
		No Natural Areas Remaining	Vulnerable
Garden Route Initiative: Vegetation layer	Provided with dataset	Critically Endangered	Highly threatened
		Endangered	Moderately threatened
		Vulnerable	Vulnerable
		Least Concern	Not threatened
Southern African Butterfly Conservation Assessment	(Mecenero *et al.* 2013)	Critically Endangered	Highly threatened
		Endangered	Moderately threatened
South African Frog Atlas Project	(Minter *et al.* 2004)	Vulnerable	Vulnerable
		Near threatened	Vulnerable
South African Reptile Conservation Assessment	(Bates *et al.* 2014)	Least concern	Not threatened
		Unknown/Data deficient	Vulnerable
Protea Atlas Project	(South African National Biodiversity Institute 2012)	Critically Endangered	Highly threatened
		Endangered	Moderately threatened
		Vulnerable	Vulnerable
		Not threatened	Not threatened
		Critically Rare	Highly threatened
		Rare	Moderately threatened
		Declining	Vulnerable
		Least concern	Not threatened
		Unknown/Data deficient	Vulnerable
Subtropical Thicket Ecosystem Project	Provided with dataset	Critically endangered	Highly threatened
		Endangered	Moderately threatened
		Vulnerable	Vulnerable
		Currently not vulnerable	Not threatened

2.3.4 Data Analysis

To run the quantitative analysis, all prepared biodiversity features were loaded into the Zonation software, together with their weighting, and analysis was carried out for the Exit Areas at a 200 x 200 m resolution. The Exit Area (i.e. the area for prioritisation) consisted of 5 343 raster grid cells.

Zonation requires the setting of a cell removal rule to determine the actual removal order of cells. The cell removal rule was set as the Additive-Benefit Function. This Function takes into account the number of species in a given cell, rather than the species that has the highest weighting (Moilanen *et al.* 2012). In this study, data on various taxonomic groups were unavailable, thus the available data used to undertake the prioritisation in effect acted as a biodiversity surrogate for those groups excluded from the study. Previous applications of Zonation which have used surrogates to represent aspects of biodiversity (Di Minin *et al.* 2013; Di Minin & Moilanen 2014) apply the Additive Benefit Function as it results in a prioritisation that has a higher representation of features on average over all features used in analysis (Moilanen *et al.* 2012). Therefore using this function in my study could potentially increase the benefits of having to use the available features as surrogates.

To ensure that connectivity between the priority areas was considered in the analysis, a Boundary Length Penalty was activated in the software. The Boundary Length Penalty determines the level of aggregation of cells by assigning a penalty if the ratio of the edge to area in priority areas is high (Di Minin *et al.* 2014). The penalty favours a lower edge to area ratio, ensuring more aggregated priority areas.

The results from the prioritisation are displayed in a colour ranked map of the Exit Area, with the landscape divided into increments of 20%. Priority areas are divided into five priority categories; Low, Low to Medium, Medium, Medium to High and High priority areas. Low priority areas indicate the lowest ranked 20% of all cells, with each succeeding category of priority being the succeeding 20% of cells. For example, if Low priority areas are the lowest ranked 20% of all cells, Low to Medium areas the subsequent 20%, continuing until the highest ranked 20% of all cells are represented as High priority areas.

2.4 Results

The analysis included a total of 68 biodiversity features. The GRI, NFEPA and STEP projects contributed nine features consisting of previously identified priority areas. Observations of 46 species from four Atlas projects were included and 13 vegetation types from the GRI project.

The prioritisation shows large spatial variation, with high priority areas scattered within the Exit Areas (Figure 2.3). Those Exit Areas situated between sections of the GRNP, or directly adjacent to the GRNP have the potential to consolidate sections of the GRNP, yet these vary greatly in their prioritisation. The majority of isolated patches and outlying Exit Areas in relation to the GRNP (Figure 2.3) are ranked between Medium and High. These areas do not directly provide connectivity to sections of the GRNP and its consolidation.

When overlain with the current land use, all Low priority areas are within commercial plantations, with the exception of a few outlying cells in the Eastern portions of the Exit Area (Figure 2.4).

From the four atlas datasets incorporated into this study, 46 species were observed within the Exit Area, with a total of 404 observations, of which PAP is the greatest contributor (Table 2.6). The distribution of species observation points does not indicate any clear correlation with prioritisation categories (Figure 2.5). Of all the species observed within the Exit Area, 87% of them are weighted as Not Threatened, 9% as Vulnerable and 4% as Moderately Threatened. No Highly Threatened species were observed within the Exit Area.

Table 2.6 The total number of species and the total number of observation of all species within each Atlas project. Only observations which fell within the Exit Area were used in analysis.

Atlas Project	Number of Species observed within the Exit Area	Number of observation for all species
Protea Atlas Project	18	365
Southern African Butterfly Conservation Assessment	6	6
South African Frog Atlas Project	8	13
South African Reptile Conservation Assessment	14	20

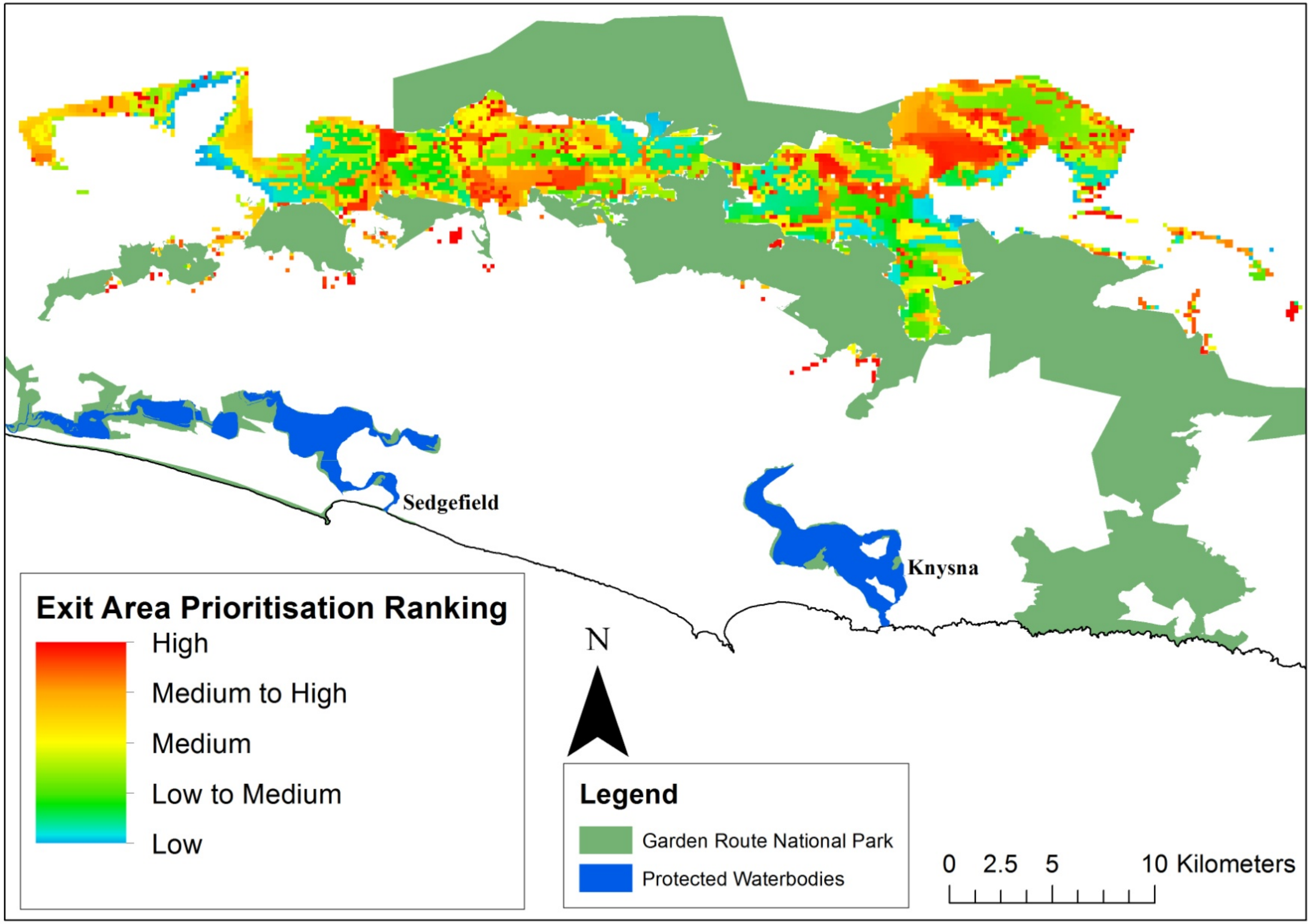

Figure 2.3 Prioritisation map of the Exit Area from the quantitative analysis. Red indicates high priority areas, yellow medium priority and blue low priority areas.

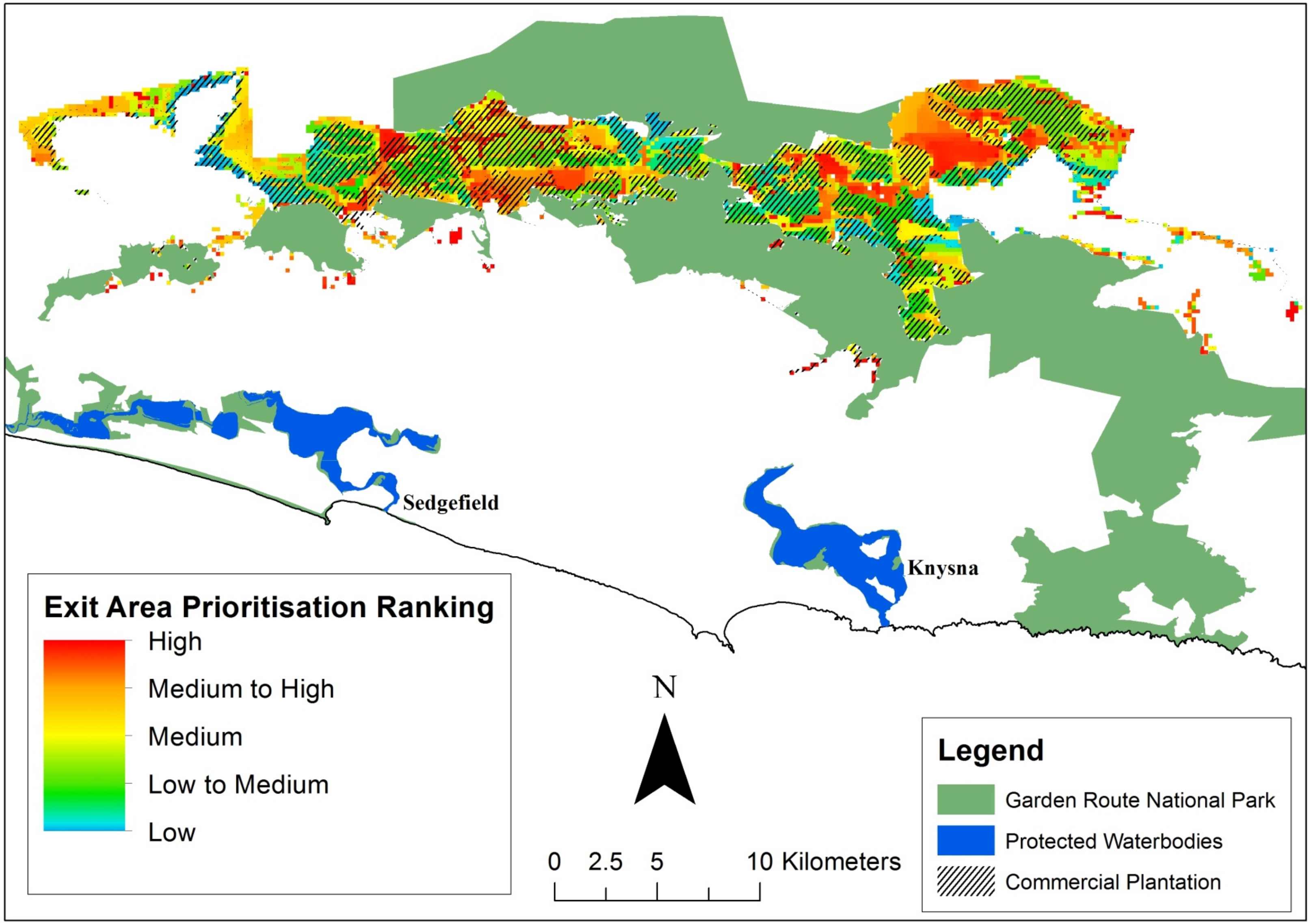

Figure 2.4 Prioritisation of the Exit Area overlain with the areas under commercial plantations.

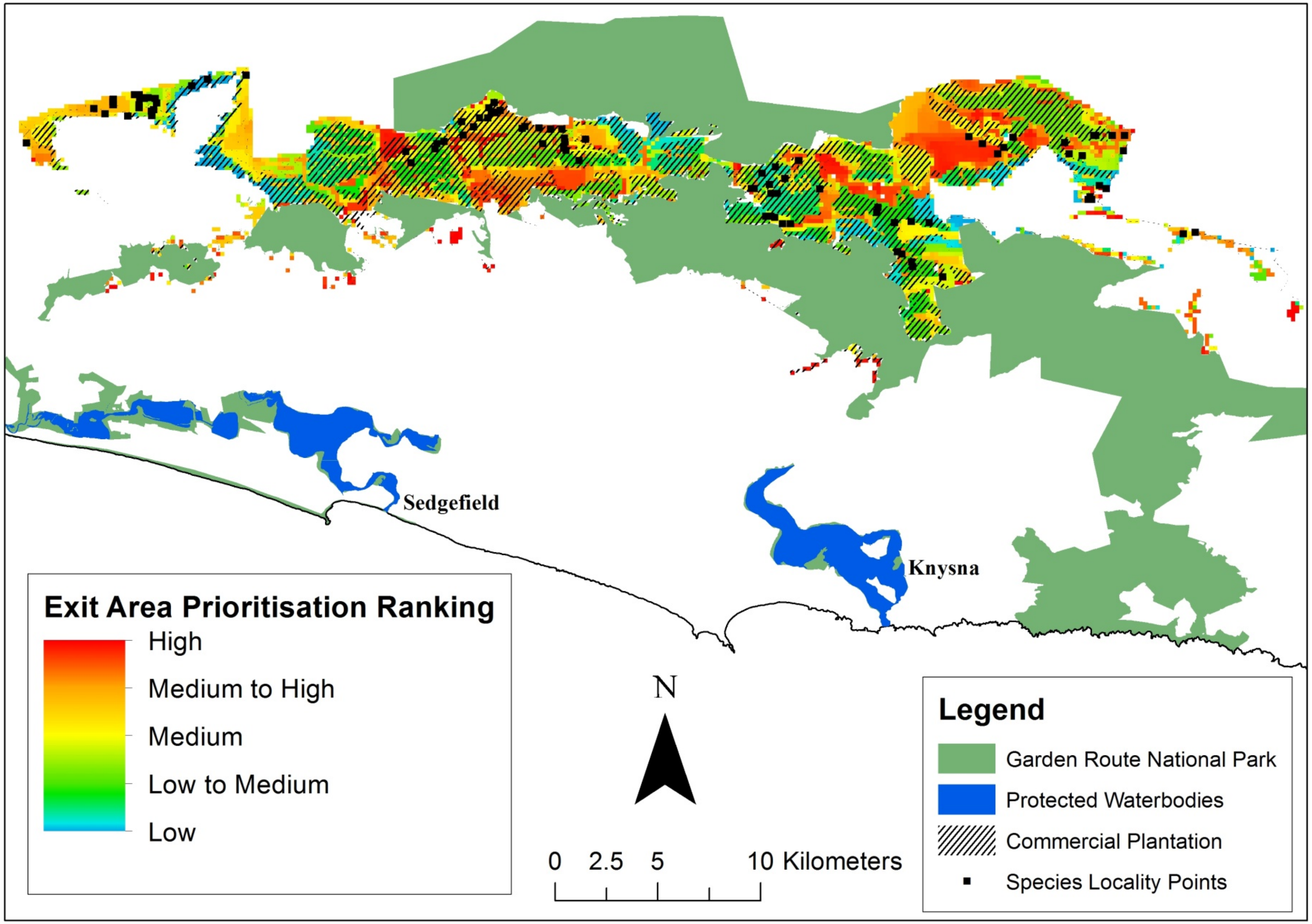

Figure 2.5 All locality points for species from all four Atlas projects included in the study, within the Exit Area.

2.5 Discussion

It is clear from the prioritisation map (Figure 2.3) that some of the areas designated for Exit are not priorities for biodiversity conservation when reviewed using a quantitative approach. The readily available data for the study area was restricted to sparse species distribution records, predicted vegetation types (Vlok *et al.* 2008), and previous prioritisations from biodiversity planning projects. Had the decision to Exit been based on a systematic conservation assessment, using the readily available data on biodiversity features within the study area, the choice of areas to be allocated for biodiversity conservation would have been different to the current allocation.

Setting priorities for biodiversity conservation, which do not follow an objective process of prioritisation for protecting biodiversity features have in some cases shown that these areas will not adequately represent species and environmental diversity (Bonn & Gaston 2005). Regionally, the configuration of protected areas in the CFR have resulted in habitat diversity and biodiversity pattern and process being poorly represented (Rouget *et al.* 2003b). This is as a result of historical allocations not being based on an objective process (Rouget *et al.* 2003b).

This study attempted to undertake an objective process of prioritisation by using appropriate, readily available biodiversity data. Limitations in the data availability required that the biodiversity features for which data were available acted as biodiversity surrogates for those features absent from the analysis. Planning for Protected Areas often requires the application of biodiversity surrogates (Margules & Pressey 2000), trade-offs occur between collecting additional data and using readily available information but there is pressure to make on-the-ground decisions (Grantham *et al.* 2009; Di Minin & Moilanen 2014). There is support for the use of cross-taxon biodiversity surrogates (i.e. using taxonomic groups for which data is available as surrogates for taxonomic groups for which no or limited data is available) (Rodrigues & Brooks 2007; Di Minin & Moilanen 2014) and the use of surrogates from multiple ecosystems (i.e. terrestrial and freshwater together) rather than a single ecosystem (Rodrigues & Brooks 2007). In this study four taxonomic groups were included, and therefore act as cross-taxon surrogates and both terrestrial and freshwater ecosystems have been included. As all appropriate, readily available biodiversity data was used in this study, it is assumed that the prioritisation presented in Figure 2.3 provides a good representation of the priority areas for all biodiversity features. This assumption remains to be tested, but is beyond the scope of this study.

Although no data on land-use was input into the analysis, available data are limited for areas under commercial forestry and it is expected that the absence of data in these areas has influenced the prioritisation. The majority of the study area is physically difficult to access and has access restrictions as it is privately managed (personal observation); therefore incomplete sampling efforts are expected for many of the Atlas datasets used. This is evident in Figure 2.5. The ecosystem disturbance that has occurred as a result of the commercial forestry land-use could also have reduced the number of species observed within these areas as no suitable habitat may be available. In addition, the GRI identified plantations within the landscape as transformed, thus excluding them in much of that prioritisation process by driving selection of planning units away from transformed areas. The absence of data in cells would results in the software allocating these cells as a Low Priority. Zonation will only prioritise empty cells that are close to cells occupied by features, even if those areas are unsuitable, as the software does not assess the availability of suitable habitat for features (Franco *et al.* 2009).

Quantitative approaches to prioritisation carry with them various well known limitations. Cowling *et al.* (2003c) undertook a comprehensive comparison on the planning outcomes of a quantitative and qualitative approach, describing the benefits and shortcomings of each approach. A major shortcoming in the quantitative approach was that biodiversity datasets are always limited (Cowling *et al.* 2003c). A quantitative approach can lead to absence of important, undocumented information, which may be crucial in the designation of priority areas for biodiversity conservation. A geographical bias based on accessibility of survey areas is discussed in both the SABCA and SAFAP projects and is said to have limited the extent of the occurrence data for those datasets (Minter *et al.* 2004; Mecenero *et al.* 2013). Such biases have been investigated by Robertson *et al.* (2010) and can be expected throughout all the datasets used. As such, these partial datasets lower the confidence in the prioritisations representation of biodiversity features. An ineffective representation of features may lead to a prioritisation that does not effectively benefit biodiversity conservation.

Another limitation in the use of the Atlas datasets is discussed by Rondinini *et al.* (2006), who argue that point occurrence data provides the least efficient solution, because such binary data does not extrapolate species presence (or absence) to un-surveyed areas. Neither does Atlas data account for the movement of species (Possingham *et al.* 2000), limiting the choice of sites for conservation to those areas where species have been recorded (Rondinini *et al.* 2006). This can affect the accuracy of the outcomes and introduce uncertainty and subjectivity into the prioritisation process. Numerous prioritisation approaches have successfully used species distribution models (Kerley *et al.* 2003; Moilanen *et al.* 2005; Kremen *et al.* 2008; Di Minin *et al.* 2013). Kerley *et al.* (2003) found that the use of the potential distribution estimates of species made the reliance on records of species occurrence unnecessary. In a prioritisation exercise undertaken for Madagascar, Kremen *et al.* (2008) used a quantitative approach using the modelled distribution of six taxonomic groups and found that the quantitative approach ensured greater representation of biodiversity.

The cell removal rule set in the Zonation analysi also influences the prioritisation outcomes. The Additive Benefit Function takes into account all species proportions in a given cell, so those cells with limited or no features are ranked lower than those with multiple features (Di Minin *et al.* 2014). This function does not take into consideration the potential of areas to provide habitat, species distribution models would have to have been incorporated for this.

The main weaknesses of this study are the incomplete Atlas data used and the exclusion of any species distribution models. Using binary data only does not account for the movement of species and can yield outcomes that may not protect as much biodiversity as one may think as a result of species migration and movement (Possingham *et al.* 2000).

An additional weakness identified to have impacted on the study is the scale of the datasets used. Scale has had an impact on the accurate representation of features within the study area. The variation in scale between the datasets and the study area can lead to inaccurate representation of features, as features are generalised across space. The NFEPA, STEP and GRI features were mapped at a broader scale than that of this study, thus their features are generalised across the portion of the study area within which they fall.

Grantham *et al.* (2009) identified that Protected Areas locations are often determined by sparse biological data. Although there may be limitations in the datasets used in this study, the quantitative analysis has produced an objective priority ranking of the Exit Area as the Zonation software aggregates the value of each cell across features, space and time (Di Minin *et al.* 2014) based on the available information. It is likely the prioritisation of the Exit Area using a quantitative results, even with the uncertainty, has still produced a more accurate prioritisation of areas for biodiversity conservation than the original Exit Strategy decision.

2.6 Recommendations

Considering the limitations discussed above, there are two key elements to consider when prioritising areas for biodiversity conservation, data quality and data surrogates for transformed or data-poor regions. Future prioritisation exercises are recommended to be strategic about their collection and management of data used. In the STEP project, data on biodiversity features was generated specifically for the study (Cowling *et al.* 2003a). Data exists in different formats, with different levels of public access and the data collected are seldom ideal for the purpose of spatial prioritisation and conservation planning (Roux *et al.* 2008). The absence of data, as well as bias associated with the datasets, has influenced the analysis, thus we need to consider that robust prioritisations cannot be made without relevant, available data on biodiversity features. A reduction in the scale of data and an increase in the sample size are recommended, atlas datasets would also benefit from the inclusion of information on data quality.

Investing in improving the quality and quantity of Atlas data would be beneficial to all future planning considering that cross-taxon surrogates are often determined to be better surrogates than environmental data (Rodrigues & Brooks 2007; Di Minin & Moilanen 2014).

For future planning within the study area, Vlok *et al.* (2008)'s perceived vegetation could be used a measure of potential vegetation following rehabilitation. The vegetation map produced as part of the GRI (Vlok *et al.* 2008) provides a good measure of potential value of transformed areas, as it identifies vegetation as it was perceived to be before European settlement. Vlok *et al.* (2008)'s data could be used as a surrogate by modelling species distributions for transformed areas based on the potential vegetation following rehabilitation. This would be able to provide a good measure of potential value of areas to biodiversity conservation.

Even though a quantitative assessment does not generate priority areas within the full extent of the Exit Area, the reality is that these areas have already been allocated to biodiversity conservation. A next step could be to assess these areas, potential benefits to biodiversity conservation based on factors such as ecosystem services, economic returns from eco-tourism activities and future expansion opportunities. Had the original Exit Strategy assessment (The VECON consortium 2006) been undertaken in such a way as this study the layout of the Exit Areas would have been different. However the potential of the low priority areas identified in this study to provide a benefit to biodiversity conservation does exist and needs to be fully realised. Global declines in biodiversity highlight the need to develop conservation strategies for regions that have already been substantially transformed by human activities (Moilanen *et al.* 2005). The biodiversity value of modified landscapes can still be high (Moilanen *et al.* 2005). The Low Priority area's potential to provide future Protected Area consolidation and form corridors needs to be assessed in the future planning of the GRNP. As not all areas to be incorporated into the GRNP are considered priorities for biodiversity conservation, the future expansion of the GRNP will need to ensure it provides the maximum benefits for biodiversity conservation (i.e. to make up for having taken responsibility for Low priority areas). A detailed assessment of the options available for expansion is recommended to ensure that future planning no longer consists of *ad hoc* allocations but rather strategic allocations to the benefit of biodiversity conservation and hence society at large.

Excluded from this method are implementation opportunities and constraints. Considering that the Exit Areas will require a level of rehabilitation to achieve their benefits to biodiversity conservation, the practical implications of such rehabilitation would be best considered by those responsible for such rehabilitation. Chapter 3 explores the inclusion of stakeholders in the prioritisation of the Exit Areas to account for those factors not included in the quantitative methods.

Chapter 3 Using Stakeholders to Determine Priority Areas for Biodiversity Conservation

3.1 Introduction

While standard methods for spatial prioritisation are based on quantifiable data, there is widespread recognition that expert opinion is equally valuable in the choice of priority areas for biodiversity conservation. Two methods of spatial prioritisation were applied in this study and this chapter presents the qualitative approach and its outcomes.

Qualitative techniques are based on the analysis of non-numerical data, identified by Gorard (2010) as most commonly dialogue and observation. For my qualitative approach, discussions with individuals from two stakeholder groups (Managers and Specialists) were used to collect data on priority areas for biodiversity conservation within the study area. The study aimed to prioritise areas for biodiversity conservation based on expert opinion and personal experience, and to determine the criteria used by individuals for prioritisation. A first step in this study was to define the stakeholders and then to develop a method of stakeholder engagement to undertake a prioritisation for the study area (see below).

In a similar study, Cowling *et al.* (2003c) selected a group of managers to undertake a prioritisation exercise for the CFR, comparing the outcomes against a quantitative approach to prioritisation. It was determined that using only a qualitative approach results in inevitable bias due to uneven knowledge, yet a qualitative approach would include valuable undocumented information (Cowling *et al.* 2003c). Pragmatic considerations played a role in determining priority areas in the CFR, yet the sample of participants influenced the prioritisation (Cowling *et al.* 2003c).

The study by Cowling *et al.* (2003c) included one stakeholder group, with individuals selected by the researchers. This MSc would be able to provide a more comprehensive review of the criteria used by stakeholders in their prioritisation of areas for biodiversity conservation by including two stakeholder groups, determined via a more robust process of snowball sampling (Hess & King 2002; Oliver 2002; Clark *et al.* 2006; Reed *et al.* 2009).

3.2 Methods

3.2.1 Selection and Definition of Stakeholders

For this study the process of stakeholder analysis (Reed 2008; Reed *et al.* 2009) was adapted to identify and define stakeholder groups for inclusion into the study. This involved three steps: (1) The definition of aspects which are affected by the decision to exit from commercial forestry to conservation land-use in the Southern Cape, (2) identification of individuals and groups who are affected by, or can affect those identified aspects and (3) prioritise those individuals and groups for involvement in the process. Each of the three steps applied in this study are defined in greater detail below. Section 3.2.2 provides details on the methods of engagement used in the study.

Step 1: Definition of stakeholder groups affected by the Exit Strategy

For this study, as the decision to Exit had already been undertaken, those stakeholders that will be affected by or can affect the Exit Strategy, either directly or indirectly were considered (Table 3.1). I was interested in the value of the Exit Area for biodiversity conservation and therefore the future management authority, SANParks, was selected as representing the group for inclusion in this study. SANParks are directly affected by the decision to Exit as they gain additional responsibility for management, and their management decisions both directly and indirectly affect additional stakeholders.

Table 3.1 Stakeholder groups determined to be affected by the Exit Strategy. The reasons for their consideration are provided.

Stakeholder groups affected by the Exit Strategy	Reason for consideration
Direct and indirect timber resource users	Shortfalls in the supply of timber to the local industry will result (De Beer 2012), affecting the secondary and tertiary forestry industries and the users of their products
Forestry Industry employees	A net loss in the direct employment opportunities is expected (De Beer 2012)
Designated future management authority	SANParks will gain additional areas to manage within the GRNP
Adjacent Landowners	A change of land use can affect the adjacent landowners by increasing/decreasing associated fire risks. A change in land ownership could also result in a change of agreements between landowners
National forestry industry	Shortfalls in the supply of timber to the local industry will results, affecting the secondary and tertiary forestry industries (De Beer 2012)

Step 2: Identification of stakeholders affecting / affected by SANParks

The second step in the stakeholder identification process described those stakeholder groups who were affected by/ can affect the management decisions taken by SANParks (Table 3.2).

Step 3: Prioritisation of groups for participation

This study aimed to prioritise areas based on their benefit to biodiversity conservation; therefore those individuals with knowledge of components of biodiversity in the region were determined to be essential for determining the Exit Areas potential value to biodiversity conservation. An additional group was also considered relevant, employees of SANParks, particularly those responsible for the management and implementation of management actions within the boundaries of the study area. Such individuals would have valuable informal knowledge as a result of practical experience and field observations which would help to determine priorities. The selection of these groups in the prioritisation exercise is in keeping with previous prioritisation approaches as traditionally, individuals with expert knowledge have played an important role in the design and implementation of all conservation planning exercises (Ferrier & Wintle 2009). The inclusion of just two stakeholder groups would also be dictated by the time limits associated with the study, as including all individuals for all groups considered would require considerable amounts of time. In addition, the selection of managers would allow the study to compare results with a similar study undertaken by Cowling *et al.* (2003c), who selected reserve managers as a group in their comparison of expert-based and algorithm-based approaches to conservation planning. The two stakeholders groups are defined as follows: (1) Specialist, those individuals who have personally collected or analysed scientific information from within the study area or individuals with knowledge of some component of biodiversity within the study site and (2) Management, those individuals whose primary mandate is the management and implementation of management actions within the boundaries of the study area.

Table 3.2 Stakeholder groups determined to affect and be affected by SANParks. The reasons for their consideration are provided.

Groups affecting/affected by SANPark's management decisions	Reason for consideration
Individuals with knowledge of components of biodiversity within the region	Individuals who have undertaken academic research on biodiversity features or have practical experience in the management of components within the region will influence management decisions made based on their observations
Direct Resource users of the GRNP	Direct resources users will create a demand for the use of various resources which require management by SANParks. Individuals may also participate in the management of the GRNP through public participation processes
Indirect resource users of the GRNP	The management activities within the GRNP will impact on aspects such as stream quality which will impact on downstream users of that resource. Individuals may also participate in the management of the GRNP through public participation processes
Employees of SANParks	Various employees make decisions on the management of areas and undertake the implementation of management actions

3.2.2 Process of Engagement

The process of engagement was designed to be undertaken in two steps, similar to the process used by Cowling *et al.* (2003c) in their prioritisation of areas for biodiversity conservation using expert opinion. For the first step individuals willing to participate in the study were consulted with at a place of convenience for the participant to undertake a prioritisation exercise. Following this, individuals willing to participate in the second step were met with individually to review the prioritisation. Participants were met with individually to avoid common bias associated with group discussions, identified by Human & Davies (2010) as resulting from (1) peer-pressure between individuals (2) the dominance of the discussion by one or more individuals (3) conflict over prioritisation decisions and (3) pressure exerted on individuals to priorities specific areas.

Prioritisation exercises were designed to achieve two outcomes. Firstly, similar to methods applied by Bryan *et al.* (2011) and Whitehead *et al.* (2014), a full colour, hard-copy map of the study area was provided indicating current land-use (Figure 2.2 in Chapter 2). Participants were asked to assess the map and provide an indication of the High, Medium and Low priority areas for biodiversity conservation within the Exit Areas. Secondly, participants were asked to motivate their choice of priority areas and the criteria they used (Cowling *et al.* 2003c) when prioritising areas the Exit Areas for conservation As an incentive for participation, these exercises were restricted to 1 hour. Individuals undertook to participate voluntarily and thus greater participation was expected if the exercise would not substantially encroach on their daily tasks.

In the review process the criteria listed by all participants in the prioritisation exercise were presented, and individuals were requested to rank each criterion in terms of their relevance to conservation prioritisation. In the review two maps were provided, the hardcopy map of the study area from the prioritisation exercise and a map with the combined prioritisation of the study area undertaken by participants in the prioritisation exercise. Participants in the review were requested to assess the maps and indicate High, Medium and Low priority areas. This review method was modified from the Delphi technique (Hess & King 2002; Oliver 2002; Clark *et al.* 2006), with the modification of the technique being that there was only one iteration of the combined map and not all participants in the first step participated in the review. As with the prioritisation exercise all meetings had a time restriction, to ensure that the meeting would not substantially encroach on participant’s daily tasks.

The three outputs of the stakeholder engagement process were (1) a prioritisation map of the Exit Areas for each participant (2) a list of prioritisation criteria identified by participants as relevant in the spatial prioritisation of the Exit Areas and (3) a ranking by each participant of all prioritisation criteria listed. The specifications of engagement with each group are detailed in this section.

The stakeholder engagement methods proposed for this study was approved by the NMMU Faculty of Science RTI Committee (Reference number H14-SCI-NRU-01, Appendix 1). The application assessed the potential risks and benefits to participants, specified the anonymity of the participants, and the confidentiality of the data collected.

Specialist Group Engagement

A list of individuals to include in the analysis was formulated by undertaking a literature search of academic journal articles, in the Natural Sciences category, under key words in the Google Scholar online search engine. The keywords used were: Garden Route National Park, Wilderness National Parks, Knysna National Lakes Area, Diepwalle, Harkerville, Gouna, Goudveld, Bergplaas, Buffelsnek, Garden Route, Southern Cape and Forestry. Publications between 1990 and 2013 were considered to ensure that the knowledge was not outdated, and the individual had to have published more than once. The number of publications was to ensure that only those with expertise on specific features were included as many publications include once-off collaborators who were involved in only specific aspects of the study. Publications were limited to studies that incorporated the study area or part of it on specific biodiversity features e.g. taxonomic groups, species and vegetation types. Broad regional scale research was not included as individuals with local, place-based knowledge were preferred (Strager & Rosenberger 2006). The library collection of published work relevant to the Garden Route National Park, which is held within the SANParks Scientific Services regional office for the Garden Route, was also reviewed based on the same criteria.

A total of only 14 individuals were identified through this process. It was concluded that the original search had been restrictive and the list of Specialists was further expanded upon using the iterative approach of snowball sampling (Durrheim & Painter 2006). Individuals were contacted via email (Appendix 2) and requested to recommend additional participants who had knowledge of components of biodiversity within the study site, and knowledge of the important factors that influence the spatial and temporal distributions of these components. In addition, local environmental organisations operating within the study area were contacted via email (Appendix 2) and requested to provide their recommendations of individuals based on the same criteria. A total of 38 individuals were identified through the original and snowball sampling process, of which 24 were contacted and requested to recommend additional participants. An additional three individuals were identified by those contacted; no new recommendations were made by these three individuals. As the same individuals were being recommended it was deemed that information saturation (Figure 3.1) had been reached and no further recommendations were requested. A total of 41 individuals were identified.

Of the total 41 individuals identified, 35 individuals identified in the Specialist group were contacted via email in April 2014 and invited to participate in the research. Individuals were provided an overview of the study, its objectives, and the requirements for participation. Other than polite, yet strong pleas for participation, no other incentive was provided for participation. Those unresponsive to the request were contacted again via email. Seven of the recommendations were received late in the research process and those individuals were not contacted due to logistical and time constraints. Nine individuals were unresponsive to both requests, five were unable to be contacted and nine were either unwilling or unable to participate. A total of 12 individuals were willing to participate in the study.

Nine Individuals, out of the 12 willing to participate, were able to undertake a prioritisation exercise for the study area. In follow-up, the 12 Specialists were again contacted during August 2014, both telephonically and via email, and invited to participate in a review of the prioritisation for the study area. Of these, seven were unwilling to participate in the review process. Five individuals responded and were able to participate in the review. Two of these individuals had undertaken the prioritisation exercise, and three were participating for the first time. A total of 12 individual prioritisation maps were produced from this group and a total of 16 prioritisation criteria were identified.

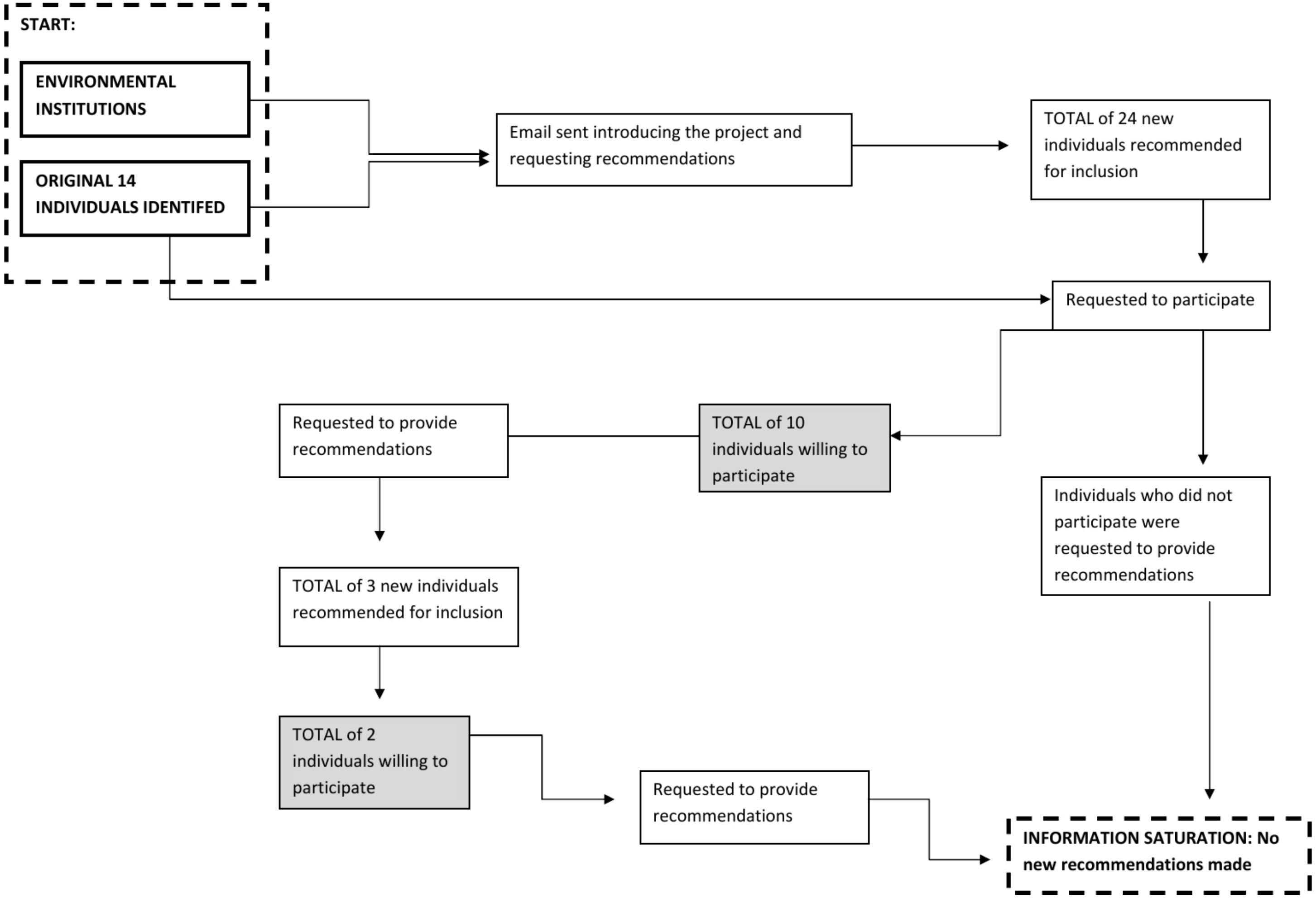

Figure 3.1 A graphical representation of the Snowball Sampling method undertaken in this study.

Management Group Engagement

A meeting was held in September 2013 with a management representative for the GRNP, with the purpose of obtaining the details of those individuals who are responsible for the management and implementation of conservation actions within the study area, as well as those responsible for the management of special projects within those areas. A total of four individuals were identified. These four individuals were contacted telephonically in April 2014. They were provided an overview of the study, its objectives, and the requirements for participation. All four individuals were willing to participate in the research and meetings were scheduled to undertake a prioritisation exercise. Following the prioritisation exercise, all four individuals participated in the review process.

The study area falls within eight management areas, delineated by SANParks for separate administration. For the prioritisation exercise undertaken with individuals in this group, the study area was delineated into the relevant SANParks management areas for ease of reference. Four individual prioritisation maps were produced from this group and one combined prioritisation map. A total of eleven prioritisation criteria were identified by individuals.

3.2.3 Data Capture

All Individual prioritisations were digitised using ArcGIS version 10.1 and converted into raster data at a cell size of 200 x 200 m. ArcGIS recommends a Default Cell Size based on the smallest possible cell size for the data being converted, the cell size for this project was determined by averaging the Default Cell Size indicated by the ArcGIS software during conversion (See Chapter 2).

Two participants from the Specialist group did not delineate specific areas on the hardcopy map for prioritisation but indicated specific biodiversity feature they would prioritise. One individual specified the prioritisation of specific vegetation types mapped by Vlok *et al.* (2008), the other specified the catchments of Rivers and Wetlands of national importance identified in Turpie *et al.* (2002) and Maree *et al.* (2003). These features were identified within the study area by the researcher and a prioritisation map for each individual was compiled.

3.2.4 Data Analysis

All individual prioritisations were combined for each group in the Zonation (Moilanen *et al.* 2012) software package. High, Medium and Low priority areas identified by each individual were exported as separate layers in a tif or ASCII format. A total of 19 layers were exported for the Specialist group and 9 layers for the Management group. Zonation undertakes prioritisation based on biodiversity features and their weighting. Each individual prioritisation layer was treated as a biodiversity feature for this analysis and the priority ranking as the weight. Each raster layer consisted of 5 343 effective grid cells of information, and each cell was assigned a weighting based on their priority. High priority cells were weighted 3, Medium priority areas 2 and Low priority areas 1. The scale of the weighting chosen was immaterial, as all that was required for input into Zonation was an indication of rank (Moilanen *et al.* 2012; Di Minin *et al.* 2014).

Zonation requires the setting of a cell removal rule to determine the actual removal order of cells. As with the quantitative analysis, this was set as the Additive-Benefit Function (Chapter 2). This function takes into account all weighting proportions in a given cell, thus treating the weighting of each cell as cumulative (Moilanen *et al.* 2012; Di Minin *et al.* 2014). Because this function sums each cell's weighting it was determined to be suitable for combining individual prioritisations as it would be able to give a combined ranking of each cell based on their relative weightings.

Connectivity was accounted for by setting a Boundary Length Penalty. The Boundary Length Penalty determines the level of aggregation of cells by assigning a penalty if the ratio of the edge to area in priority areas is high. The penalty favours a lower edge to area ratio, ensuring more aggregated priority areas (Moilanen *et al.* 2012; Di Minin *et al.* 2014).

The results from the combined prioritisation are displayed in a colour ranked map of the Exit Area, with the landscape divided into increments of 20%. Priority areas are divided into five priority categories; Low, Low to Medium, Medium, Medium to High and High priority areas. Low priority areas indicate the lowest ranked 20% of all cells, with each succeeding category of priority being the succeeding 20% of cells. For example if Low priority areas are the lowest ranked 20% of all cells, Low to Medium areas the subsequent 20%, continuing until the highest ranked 20% of all cells are represented as High priority areas.

In the prioritisation exercise, participants were requested to define the criteria used for determining priority areas, similar to those methods undertaken by Cowling *et al.* (2003c) where individuals were required to provide a justification for their choice of priority areas. In the review process, all criteria used by participants were listed and participants were requested to rank these in terms of their relevance to conservation prioritisation. These results were used to determine the relationship between the criteria and the stakeholder groups.

The criteria used by individuals in the prioritisation exercise were investigated to account for the differences seen in prioritisation maps between the groups. A Non-metric Multidimensional Scaling (MDS) ordination was used to visualise the difference between individuals, based on Bray-Curtis resemblance matrices (Clarke 1993; Clarke & Gorley 2006). The MDS analyses was run to graphically represents the relationship between the participants from each group in relation to their use of prioritisation criteria. The relationship is presented in two dimension, with points close together representing individuals which are very similar in their use of criteria, while those far apart correspond to the use of a different set of prioritisation categories. A multi-response permutation procedure using Analysis of Similarity (ANOSIM) was used to test the difference in the use of prioritisation categories between groups (Clarke & Gorley 2006). The ANOSIM analysis was run as a one-way analysis, using 5000 permutations to obtain an R and *p* value (Landman *et al.* 2013). The *p* value indicates the statistical significance and an R value the difference among groups. The R value is constrained to the range -1 to 1; positive values indicating differences among groups (Clarke & Gorley 2006). A Bray-Curtis ordination using Similarity Percentages (SIMPER) was used to identify those criteria primarily providing the dissimilarities between the groups in the prioritisation exercise (Clarke 1993). SIMPER also identifies prioritisation criteria primarily providing the similarities between individuals within each group, a percentage of similarity is calculated for those criteria primarily contributing to similarity within the group. All statistical analysis was undertaken using Primer version 6 (Clarke & Gorley 2006).

Particpants either used a criterion for prioritisation or did not, thus binary data were collected for each particpant. For analysis in Primer, binary data are treated as presence/absence. If an individual used a criterion in the prioritisation of areas it was marked as 1. Absence was marked as 0. Individual particpants were the samples and stakeholder groups the treaments.

A second analysis was run in Primer (Clarke & Gorley 2006) to determine the criteria considered relevant in the spatial prioritisation for each group. In the review process, particpants were asked to rank all the prioritisation criteria in terms of their relevance to spatial prioritisation. As participants had been requested to rank criteria as either relevant or irrelevant, binary data were developed and as with the previous Primer analysis, the data were treated as presence/absence. If an individual ranked a criterion as relevant for prioritisation, the respective planning criterion was marked as 1. Absence was marked as 0. Individual particpants were the samples and stakeholder groups the treatments, prioritisation categories were the variables. The SIMPER analysis was run with the results from the criteria ranking undertaken in the review process, identifying the prioritisation categories primarily providing the dissimilarities between the two stakeholder groups (Clarke & Gorley 2006). SIMPER also identifies prioritisation criteria similarly ranked between individuals within each group; a percentage of similarity is calculated for those criteria primarily contributing to similarity within the group.

3.3 Results

The qualitative analysis yielded a prioritisation map for each stakeholder group clearly indicating the differences in the delineation of priority areas between groups. The Specialist prioritisation does not indicate any obvious spatial pattern, with the distribution of High priority areas spread throughout the Exit Area and variation in the prioritisation of isolated patches (Figure 3.2). In contrast the Management prioritisation has clearly favoured those Exit Areas enclosed by or adjacent to sections of the GRNP, with the exception of some high priority areas in the outlying Eastern and Western portions (Figure 3.3). The areas situated between sections of the GRNP are considered the central areas. In general, the Managers' prioritisation has yielded defined patches of High priority, while the Specialists' High priority areas are spread unevenly across the Exit Area.

Obvious differences are evident in the ranking of central and Eastern portions of the Exit Area. High priority areas for Managers are concentrated in the centre of the Exit Area. This area is ranked between Low and Medium for the Specialist group. In the Eastern portion of the Exit Area, the Specialist ranking varies between High and Medium; the Managers rank the same portion between Low and Medium priorities. There is a small area identified by managers as high priority within the Eastern portion, however its placement is distinct from the placement of High priority areas by Specialists in the same area. Similarities between groups are visible in the ranking of isolated patches of the Exit Area. In both groups that majority of patches are ranked between Medium and High, with a few isolated cells of Low rank. The two maps were not combined into one stakeholder map as I considered the differences between the groups relevant to note, and wished to investigate the differences between the prioritisations.

The differences between groups were investigated by determining the relationship between each group and their use of prioritisation criteria. A total of 27 prioritisation criteria were used by participants when prioritising the Exit Areas for biodiversity conservation. Criteria were motivated either due to specific features or conservation functions being of importance to individuals, or due to specific management considerations being taken into account when prioritising areas. All criteria were subsequently categorised for ease of analysis (Cowling *et al.* 2003c), the criteria were grouped into 9 broad categories based on their prioritisation of features, conservation functions or management consideration (Table 3.3).

The Specialist group was found to prioritise the Exit Areas based on the potential to create corridors, provide consolidation and based on botanical features (Table 3.5). Managers prioritised areas based only on the potential to provide consolidation and on various operational considerations (Table 3.6). The ANOSIM analysis found that the difference ($R = 0.085$) between the use of criteria in the prioritisation exercise, was not significant ($p = 0.235$). The relationship between individuals does not show any clear pattern in the MDS analysis (Figure3.4). The distance between individuals within the same group is inconsistent and often larger than the distance between individuals from different groups. Two participants from the Specialist group prioritised areas using identical criteria during the prioritisation, shown in Figure 3.4 as overlapping points.

Upon review of all prioritisation criteria, the Management group specified that prioritisation should be based on considering the aquatic and botanical features, the existing state of features within the planning domain and the potential to create corridors (Table 3.8). In contrast the Specialist group considered prioritisation based on aquatic features, botanical features and the consolidation of areas as relevant to the prioritisation of areas for biodiversity conservation (Table 3.9). The dissimilarity between groups was as a result of their differences in considering the categories of financial considerations, species of special concern, operational considerations and catchment boundaries as relevant.

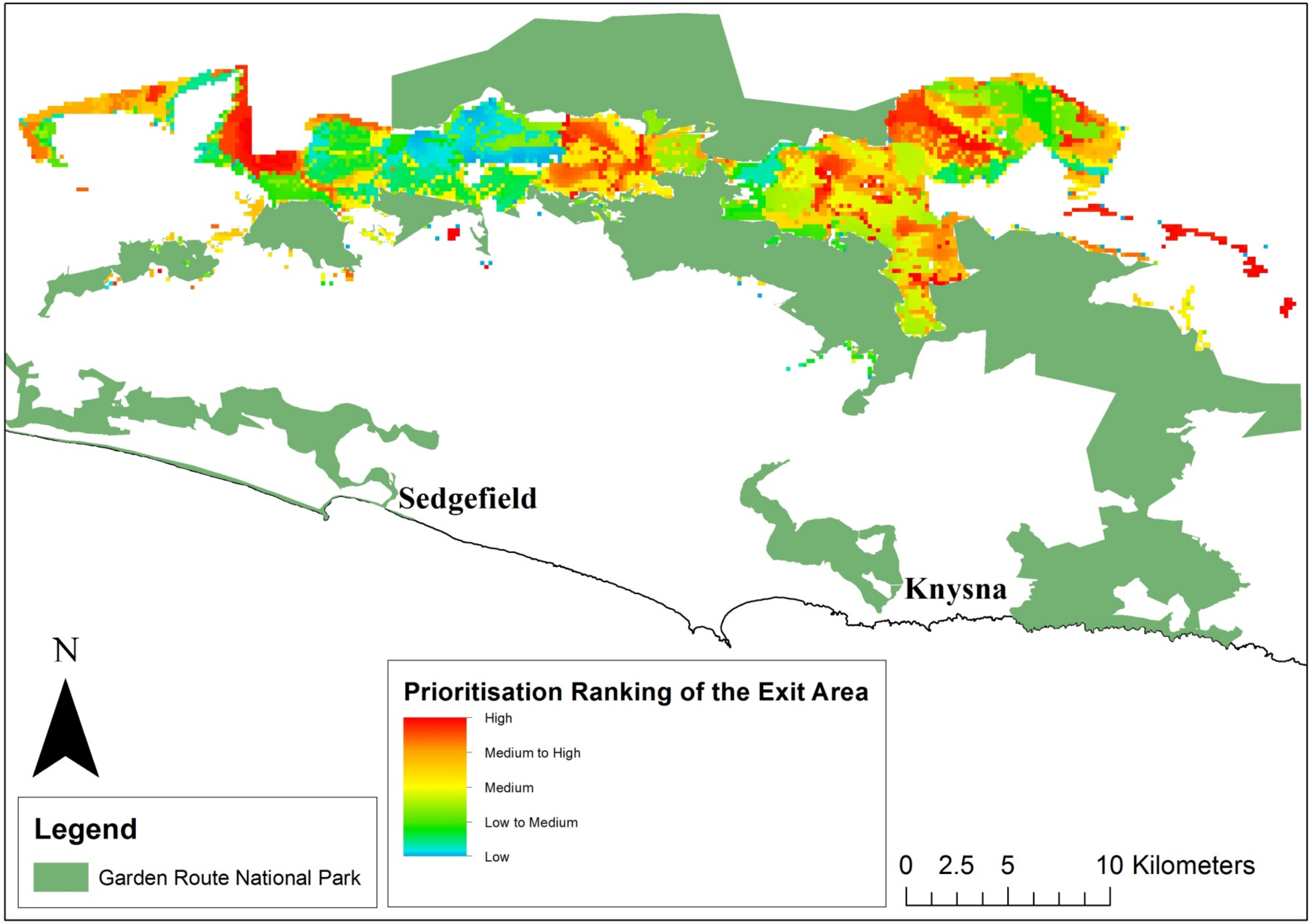

Figure 3.2 Specialist prioritisation map. This map is a combination of all individual prioritisations within the group. Red indicates high priority areas, yellow medium priority and blue low priority areas.

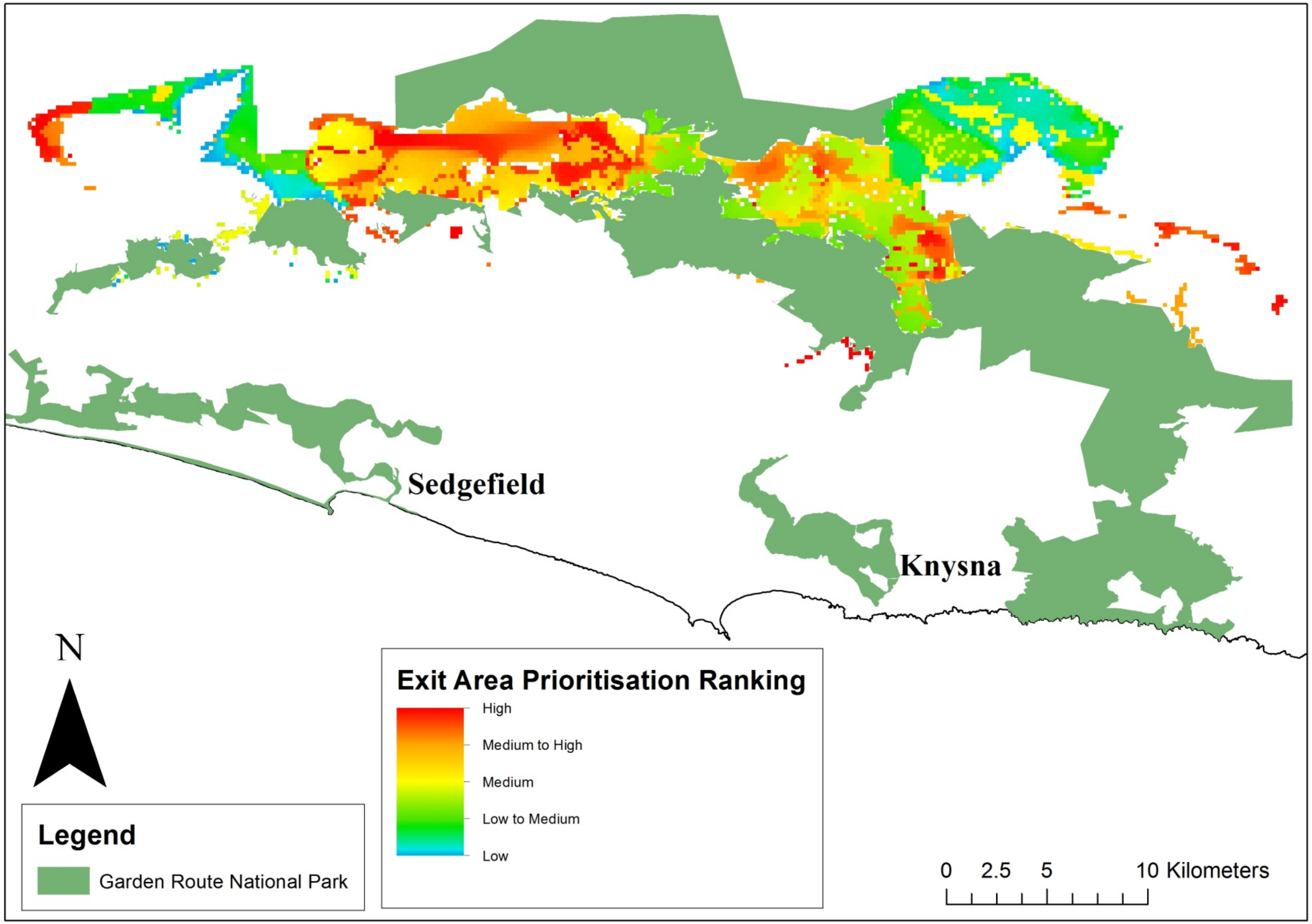

Figure 3.3 Management prioritisation map. This map is a combination of all individual prioritisations within the group. Red indicates high priority areas, yellow medium priority and blue low priority areas.

Table 3.3 Prioritisation categories grouped for analysis. The original planning criteria listed by individuals are shown in column 2 and the stakeholder group which originally identified the criteria is given in column 3.

Prioritisation categories	Original prioritisation criteria	Stakeholder group
Financial considerations	Financial constraints on the management of areas	Management
	Operational costs per hectare	Management
Catchment boundaries	Areas incorporating entire catchment boundaries	Management
Operational considerations	Accessibility	Management
	Potential management boundary shape to be created	Management
	Area to boundary ratio to ease management requirements	Specialist
	Potential requirements for fire management	Management
Consolidation	Consolidation of existing Protected Areas	Management and Specialist
	Distance from existing National Park	Management
	Consolidation to ease fire management	Management
	Park expansion targets	Management
Corridors	Creation of East-West running corridors	Management
	Potential of an area to create corridors	Specialist
	Consolidation of North-South running corridors	Specialist

Table 3.3 continued

Prioritisation categories	**Original prioritisation criteria**	**Stakeholder group**
Aquatic features	Wetlands	Specialist
	Riverine buffers	Specialist
	Consolidation of the upper reaches of the estuaries and rivers of National importance	Specialist
Botanical features	Areas with high botanical species richness	Specialist
	Potential vegetation type following rehabilitation	Specialist
	Areas containing high altitude fynbos	Specialist
	Connectivity between vegetation types	Specialist
Existing features within the planning domain	Large, intact areas abutting Protected Areas	Specialist
	Age of plantation	Specialist
	Natural state of land adjoining the area considered for inclusion	Specialist
	Size of intact areas of indigenous vegetation within the planning domain	Management
Species of special concern	Potential to create refugia for bird species	Specialist
	Areas with high proportions of species of special concern	Specialist

No clear relationship was evident in the MDS analysis, the distance between points shows no pattern between individuals from each group (Figure 3.4), the R value indicates a difference between groups yet this difference is indicated as statistically insignificant (*p* =-0.235, Figure 3.4)

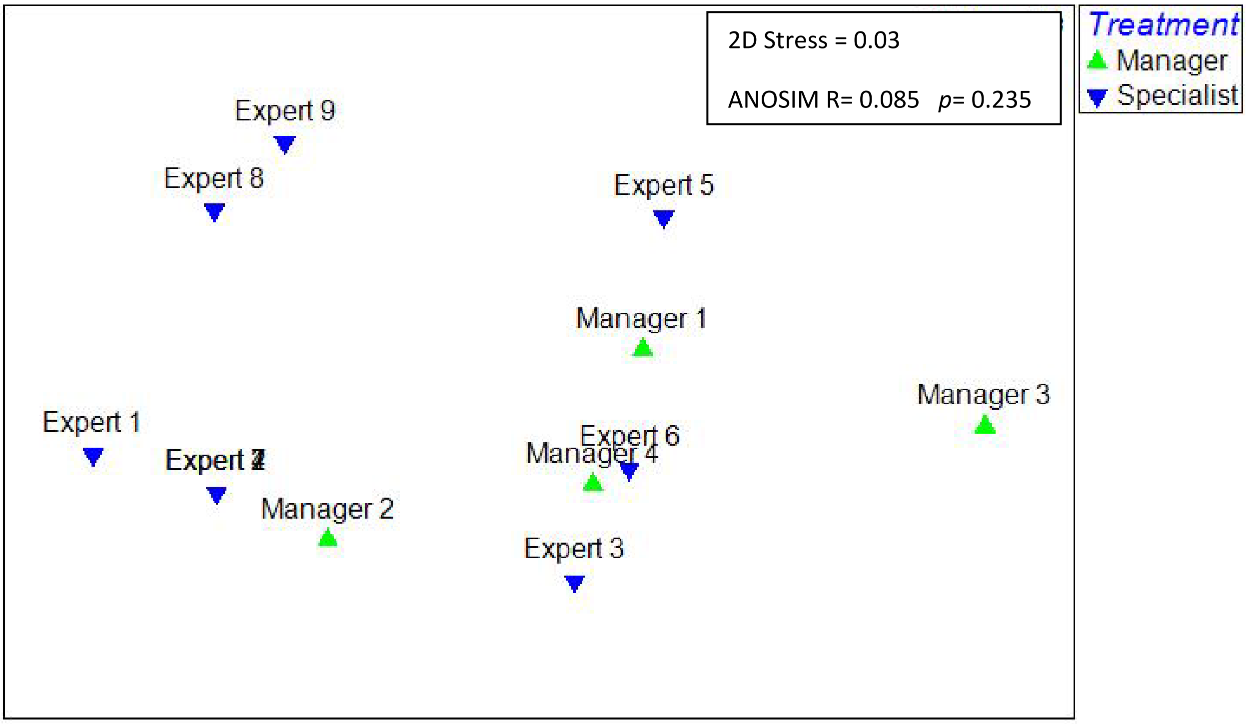

Figure 3.4 Non-metric Multidimesional Scaling ordination of the use of planning categories between the individuals of each group. ANOSIM (Analysis of Similarity) *R* vlaues indicates the degree of separation across groups/treaments. Expert 4 and 2 are directly overlain as their use of prioritisationc categories was identical.

The average dissimilarity between the stakeholder groups in their prioritisation is calculated as 65.41%, with eight categories causing the dissimilarity. Displayed in order of decreasing contribution to the between-group dissimilarity, Table 3.4 shows that the categories of operational considerations, corridors, botanical features and consolidation provide the greatest contribution to this dissimilarity.

Table 3.4 Similarity Percentages for the dissimilarity between stakeholder groups in the prioritisation exercise. The contribution of each category to the average dissimilarity between groups is shown in column two and a cumulative contribution in column three.

Prioritisation category	Contribution (%)	Cumulative contribution (%)
Operational considerations	16.0	16.0
Corridors	16.0	32.0
Botanical features	15.1	47.1
Consolidation	13.3	60.4
Existing features within the planning domain	11.7	72.1
Aquatic features	8.9	81.0
Financial considerations	6.4	87.4
Catchment boundaries	6.4	93.8

The SIMPER analysis also identified the prioritisation categories primarily providing the similarities between individuals within each group in the prioritisation exercise (Tables 3.5, 3.6). The average similarity within the Specialist group is 40.6%, and 40.6% for the Management group. The criteria are listed in order of decreasing contribution to the similarity between individuals.

Table 3.5 Similarity Percentages between Specialists in the prioritisation exercise. Column two indicates the percentage contribution and column three the cumulated contribution of each category to the average similarity.

Prioritisation category	Contribution (%)	Cumulative Contribution (%)
Corridors	32.6	32.6
Consolidation	22.8	55.4
Botanical features	21.5	76.9
Operational consideration	7.6	84.5
Existing features within the planning domain	7.0	91.5

Table 3.6 Similarity Percentages between Managers in the prioritisation exercise. The second column indicates the contribution of each criterion to the average similarity. A cumulative contribution is given in column three.

Prioritisation category	Contribution (%)	Cumulative Contribution (%)
Consolidation	53.4	53.4
Operational consideration	46.6	100

Upon review of all the criteria, the ranking of criteria by individuals as either relevant or irrelevant indicated an average dissimilarity of 29.5% between the groups. Eight categories provide the dissimilarity between stakeholder groups, as a result of differences in the ranking of each criterion between groups. Four categories provide the greatest contribution to this dissimilarity (Table 3.7).

Table 3.7 Similarity Percentages between the stakeholder groups in the review process. The second column indicates the contribution of each category to the average dissimilarity between groups. A cumulative contribution is given in column three.

Prioritisation category	Contribution (%)	Cumulative contribution (%)
Financial considerations	17.0	17.0
Species of special concern	14.5	31.5
Operational considerations	14.5	46.0
Catchment boundaries	13.4	59.4
Existing features within the planning domain	11.2	70.6
Corridors	10.6	81.2
Consolidation	7.2	88.4
Botanical features	6.1	94.5

The SIMPER analysis also identified those categories ranked similarly between the participants from each stakeholder group (Tables 3.8 and 3.9). The average similarity in the ranking of criteria between individuals in the Management group is 79.7%. For the Specialist group the average similarity is 61.3%. For each group, only seven categories are considered relevant by individuals, three of which are relevant to both groups (Tables 3.8 and 3.9).

Table 3.8 Similarity Percentages within the Management group in the review process. The second column indicates the contribution of each criterion to the average similarity. A cumulative contribution is given in column three.

Prioritisation category	Contribution (%)	Cumulative Contribution (%)
Corridors	17.9	17.9
Aquatic features	17.9	35.8
Botanical features	17.9	53.7
Existing features within the planning domain	17.9	71.6
Financial considerations	8.5	80.1
Consolidation	8.5	88.6
Species of special concern	8.5	97.1

Table 3.9 Similarity Percentages within the Specialist group in the review process. The second column indicates the contribution of each criterion to the average similarity. A cumulative contribution is given in column three.

Prioritisation category	Contribution (%)	Cumulative Contribution (%)
Consolidation	29.5	29.5
Aquatic features	17.2	46.7
Botanical features	16.4	63.1
Catchment boundaries	8.7	71.8
Corridors	8.7	80.5
Operational considerations	8.2	88.7
Existing features within the planning domain	8.2	96.9

3.4 Key Findings

It is clear from both stakeholder group prioritisation maps presented in this chapter that not all areas have been determined as priorities for biodiversity conservation. In addition there is variation between the stakeholder groups, accounted for by the use of different criteria when prioritising the Exit Areas (Table 3.4). Managers prioritised areas based on operational considerations and the potential to provide consolidation. Specialists were varied in their use of prioritisation criteria and prioritised areas based largely on the botanical features, potential for consolidation and to create corridors. Although differences were identified in the SIMPER analysis, the MDS analysis (Figure 3.4) indicates no clear relationship between the use of prioritisation criteria and the individuals within each group, with the ANOSIM results (Figure 3.4) indicating no significant difference between the two groups, which is thought to be as a results of the small sample size.

The SIMPER analysis had a two-fold function; one used the analysis to account for the differences seen in the outcomes (Figure 3.1 and 3.2) of the prioritisation exercise, and the second was to determine the broad categories considered relevant by stakeholders groups in all prioritisations for biodiversity conservation.

Following a review of all criteria, the Management group indicated that the prioritisation of areas based on aquatic and botanical features, the potential to create corridors and the existing features within the planning domain are most relevant. Upon review of all criteria the Specialist group again considered botanical features and consolidation, but included the creation of corridors as relevant for consideration when prioritising areas for biodiversity conservation.

3.5 Discussion

The nature of the decision to Exit led to the hypothesis that not all areas designated for Exit would be determined priority areas when reviewed using a qualitative approach. This study shows that had the decision to Exit been undertaken in consultation with the stakeholder groups used in this study; the choice of areas to be allocated for biodiversity conservation would have been different to the current allocation. Moreover, the choice of stakeholder group used would also have influenced the priority area allocations. It was expected that differing approaches to spatial prioritisation would have a different outcome for the Exit Area, as the prioritisation was based on valuing the areas for alternative purposes than the original Exit decision. The large variation between groups was not expected and the difference in their use and ranking of criteria was interesting to note.

It is expected that the results from both groups are influenced by the knowledge and expertise of the individuals participating. Such influences have been previously identified in the conservation planning and prioritisation literature (Cowling *et al.* 2003c; Knight & Cowling 2007; Ferrier & Wintle 2009; Human & Davies 2010). Participation in the Specialist group was limited by individual willingness and availability to do so. The planning criteria used by participants in this group, and thus the prioritisation outcomes, could be expected to be biased in relation to the relevant expertise of the participants. The potential bias associated with expert opinion was also identified by Cowling *et al.* (2003c) as being attributed to uneven knowledge of regions and taxa. The Management group can be expected to show similar influences, based on the personal experience and expertise of the participant. Different management areas have varied management requirements and the allocation of priority areas by Managers may be influenced by their personal experience in their relevant management areas. The bias associated with reserve managers was also highlighted by Cowling *et al.* (2003c), who attributed it to personal experience in the implementation and management of conservation areas.

The unclear distinction between the two groups in the MDS analysis and the insignificant ANOSIM results could be indicative of the biases associated with the participants, coupled with the limited number of participants. Previous spatial planning studies have included extensive amounts of stakeholders from numerous groups (Human & Davies 2010; Gopnik *et al.* 2012; Whitehead *et al.* 2014) while this study was limited to only 12 participants. Limited participation is seen as a weakness in this studie’s application of a qualitative method.

In a study comparing priority conservation areas in the CFR identified by park managers and reserve-selection software using environmental surrogate data, Cowling *et al.* (2003c) highlighted the trade-off Managers make between reserve consolidation and boundary rationalization at the expense of reaching biodiversity targets. Although my study did not review biodiversity targets, my results indicate that the planning criteria aimed at consolidation and the creation of corridors contributes the highest percentage of similarity within both the Management and Specialist group, respectively. In their study, Cowling *et al.* (2003c) found that managers planned for botanical features, consolidation and aquatic habitats. This is confirmed in my finding that managers desired to improve management efficiency when planning for biodiversity conservation, as 46.6% of the managers used operational considerations during the prioritisation exercise.

Upon review of all prioritisation criteria, the stakeholder groups still differed in their consideration of relevant criteria. Planning with only one of the stakeholder groups could result in the prioritisation not considering species of special concern, financial considerations and other operational considerations (Table 3.7). Different stakeholders clearly prioritise areas for biodiversity conservation based on a different value of criteria to consider. This highlights the need to account for knowledge gaps and bias in the use of stakeholders.

3.6 Recommendations

The results indicate that the choice of stakeholder groups will impact significantly on results. Such influences and associated bias need to be recognised and future prioritisation needs to ensure the choice of stakeholder is justified (Pomeroy & Douvere 2008). It is recommended that a full representation of all relevant stakeholders become a requirement for all future prioritisation which engage with stakeholders.

For this study logistical restrictions excluded some individuals from participating, however future prioritisation can make use of a variety of stakeholder engagement methods (Reed 2008) in an attempt to include all individuals identified. Past studies suggest that stakeholder participation can improve the quality of environmental decisions (Cowling *et al.* 2003c; Cowling *et al.* 2004), but the quality of the decisions made is dependent on the quality of the process that leads to it (Reed 2008). A more robust method of stakeholder engagement may aid in reducing bias and ensuring a prioritisation based on all available expert knowledge and relevant socio-economic considerations.

The operational considerations highlighted by participants are not new to planning, and numerous literature sources have dealt with including implementation and management consideration in conservation planning and prioritisation practices (Cowling *et al.* 2003c; Cowling *et al.* 2004). The consideration of operational requirements is realistic in the allocation of areas for conservation. Future conservation planning and prioritisation may benefit from including the constraints associated with the conservation of areas under consideration, and thus the choice of priority areas designed around the limitation identified e.g. financial and expansion targets. In this way, one can plan to maximise biodiversity given the limitations (Possingham *et al.* 2000).

Chapter 4 Synthesis and Discussion

The nature of the decision to allocate these areas to the Exit Strategy led to the hypothesis that should this decision have been undertaken considering the land's value for biodiversity conservation rather than forestry, then not all the Exit Areas would be considered priorities and would not all have been allocated to biodiversity conservation. I undertook a prioritisation process to assess the value of the Exit Areas to biodiversity conservation. These prioritisations were based on the readily available data and expert knowledge on biodiversity features, and provided a means of undertaking a prioritisation of the Exit Areas based on their known and perceived value to biodiversity conservation. The results from both approaches indicate that the Exit Area, in its entirety, is not a priority area for biodiversity conservation. The original decision to Exit from commercial forestry to conservation land –uses was made based on the value of the land to the forestry industry, suggesting that in the current era of Systematic Conservation Planning, the allocation of protected status to areas may still occur as a result of perceived limited benefit to anthropocentric needs from these areas. Historical allocations based on their perceived benefit have resulted in conservation areas containing biased samples of ecosystems and habitats (Rouget *et al.* 2003b; Mackey *et al.* 2008; Joppa & Pfaff 2009).

Historical allocations within the study area and the greater CFR have been *ad hoc* allocations based on the land not being in demand for an alternative anthropocentric use (Cowling *et al.* 2003b; Rouget *et al.* 2003b). The results from my analysis suggest that the *ad hoc* allocation of the Exit Areas have not generated priority areas for biodiversity conservation, possibly leading to more of the bias previously identified for the region (Cowling *et al.* 2003b; Rouget *et al.* 2003b).

The two methods used in this study enabled the comparison of two differing prioritisation techniques. The results show that in each approach, not all of the areas designated for Exit are priorities for conservation. To compare the prioritisation outputs between approaches two post processing analyses were run to compare the spatial overlaps between each approach (i.e. the overlap between identically ranked cells). Both analyses were undertaken in Zonation, the first produced a comparison of the High priority areas for each prioritisation by calculating the percentage overlap of High Priority cells between approaches (Di Minin *et* *al.* 2013). The second analysis merged the full prioritisation maps produced from each approach and calculated the percentage overlap of cells between each (Di Minin *et al.* 2014).

Determining the spatial overlap of High priority areas was undertaken in Zonation by comparing the percentage of overlapping grid cells in High Priority area for each respective prioritisation maps (i.e. the overlap of the top 20% ranked cells for each prioritisation). Priority areas determined through the quantitative analysis show a patchy distribution of High priority areas spread unevenly throughout the Exit Area (Figure 2.3). The qualitative analysis using the Specialist group also showed an uneven distribution of High priority areas, yet the Management group prioritised defined areas, concentrated between existing areas of the GRNP (Figure 3.2 and 3.3). The greatest similarity in the placement of High priority areas is between the Specialist group and quantitative analysis, the least similar allocation of High priority areas is between the Management group and quantitative analysis (Table 4.1).

Table 4.1 The percentage overlap of High priority cells between prioritisation approaches.

Comparison	Percentage overlap (%)
Specialist group and Management group	37.3
Specialist group and quantitative analysis	38.8
Management group and quantitative analysis	36.7

To run a comparison between the full Exit Areas prioritisation, I merged the prioritisation maps between each method to be able to determine the overlap between the different maps (Di Minin *et al.* 2014). The comparison was run in Zonation and required the landscape to be divided into the top 50% of all cells and the bottom 50% of the all cells. In the merged maps, black areas represent those areas rated in the top 50% of the landscape in both methods, and light grey those areas rated in the bottom 50% in both methods (Di Minin *et al.* 2014). A difference in allocation between the methods, and thus an overlap in colour, is represented by a dark grey colour.

Table 4.2 Percentage of overlapping grid cells for the top 50% (above and right of dashes) and the bottom 50% (below and left of dashes) of the Exit Area according to the respective Zonation priority-ranking results.

	Management	Specialist	Quantitative
Management	-	27.42	27.91
Specialist	26.43	-	34.75
Quantitative	27.62	34.66	-

The greatest difference in prioritisation is between the Management and Specialist group (Figure 4.1), and the prioritisations that are the most similar in their ranking are the Specialist group and the quantitative analysis (Figure 4.2). Specialist opinion is influenced to a large degree by the available data used in the quantitative analysis, specialists may have worked with or contributed to some of the datasets (Minter *et al.* 2004; Nel *et al.* 2011; Mecenero *et al.* 2013; Bates *et al.* 2014) and conservation plans used in the analysis. This may explain the similarities found between the Specialist group and the quantitative analysis in both their allocation of High priority areas and in their full prioritisation. As the two stakeholder groups undertook their prioritisation using contrasting criteria, the difference between the group prioritisations is expected to be as a result of the varied experience and expertise between individuals from each group.

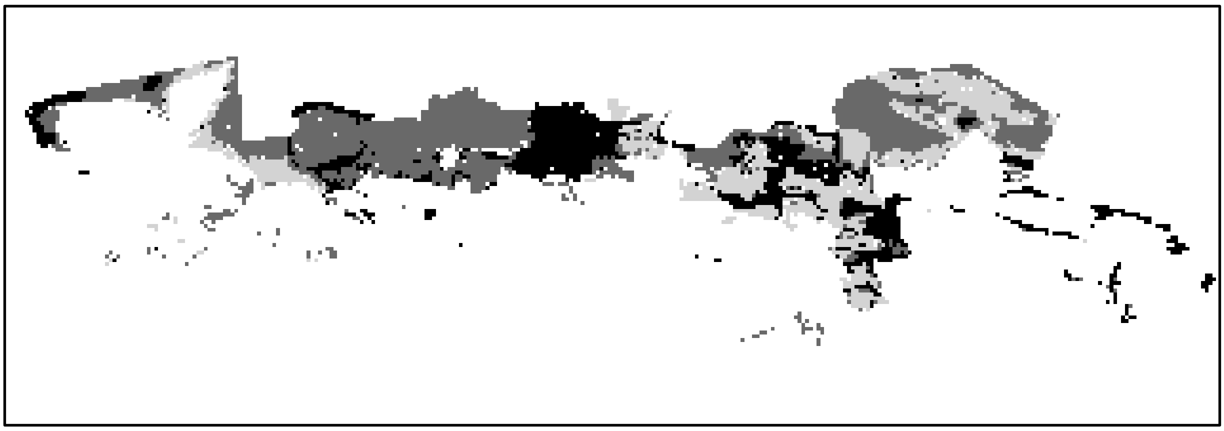

Figure 4.1 Merged prioritisation maps of the Specialist and Management groups. Differences in allocation of priority areas are represented by a dark grey colour.

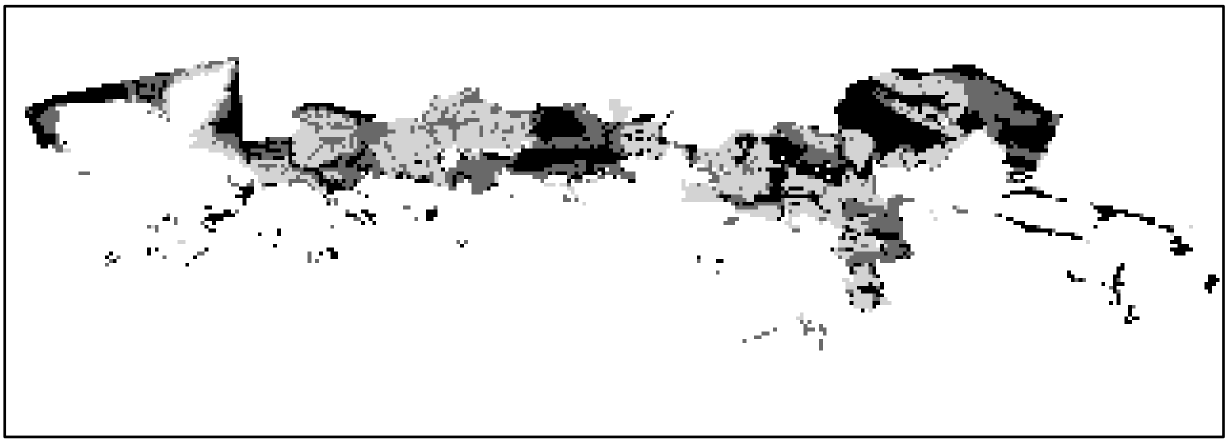

Figure 4.2 Merged prioritisation maps of the Specialist group and the quantitative analysis. Differences in allocation of priority areas are represented by a dark grey colour.

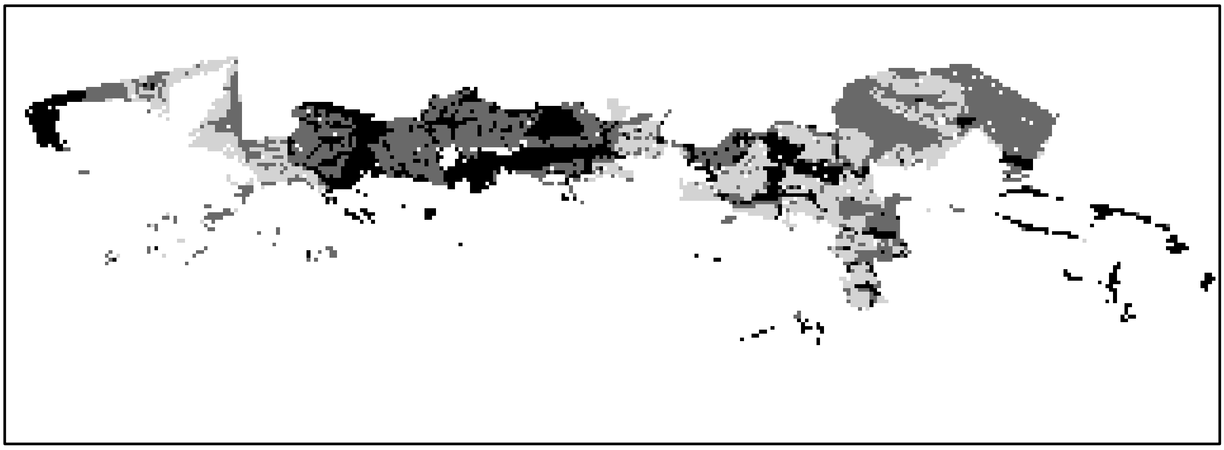

Figure 4.3 Merged prioritisation map of the Management group and the quantitative analysis. Differences in allocation of priority areas are represented by a dark grey colour.

The quantitative analysis in this study incorporated all readily available biodiversity data, and used these as surrogates for taxonomic groups absent from the analysis. However, data are deficient for the areas currently under commercial plantations. Cells lacking biodiversity feature data are automatically allocated as Low priorities by the software. The inclusion of modelled data on species distribution could have influenced the prioritisation by including data for those areas under commercial plantation. The allocation undertaken by the software and the absence of species distribution data in this study limited the objective identification of priority areas (Possingham *et al.* 2000; Grantham *et al.* 2009). Priority areas identified using solely quantitative approaches have historically poor records of implementation (Cowling *et al.* 2004; Knight & Cowling 2007), largely attributed to such methods not successfully incorporating social-ecological factors (Cowling *et al.* 2004; Knight

& Cowling 2007; Moilanen *et al.* 2009d) and disregarding implementation opportunities and constraints (Cowling *et al.* 2003c). The incorporation of qualitative approaches together with the quantitative approach may have increased the objectivity of the outputs by incorporating information not available as quantifiable data.

Similar to the benefits of a qualitative approach assessed by Ferrier & Wintle (2009), in my study, the inclusion of stakeholders were useful to rapidly identify priorities in a region where data were coarse and incomplete. Both groups in the qualitative analysis were able to incorporate undocumented information that was not readily available for the quantitative analysis. Distribution models for biodiversity features were not incorporated into the quantitative analysis. The incorporation of such information would have been able to provide a measure of the potential benefit the Exit Areas may have for species distribution. In the qualitative analysis participants were able to assess the potential benefit of the Exit Areas based on their knowledge of the area and the expected distribution of biodiversity features. The Specialist group considered an area's potential to create corridors and provide for consolidation of the GRNP in their prioritisation, and the Management group considered the potential to provide consolidation of the GRNP. However, personal expertise and knowledge may have given preference to particular regions and knowledge about specific biodiversity features. Such bias was also identified by Cowling *et al.* (2003c) and Lehtomäki *et al.* (2009). In their study, Cowling *et al.* (2003c) suggested that the focus on improving the design of priority areas through considering consolidation resulted in a substantial portion of priority areas not contributing to conservation targets for biodiversity features. The focus on consolidation by both stakeholder groups in my study could result in their prioritisations not being fully representative of biodiversity features, as identified by (Cowling *et al.* 2003c).

Stakeholder participation can allow for more comprehensive information on social, economic and political factors (Reed 2008), which is partially shown in the Managers' prioritisation based on operational considerations. Yet prioritisation favouring such categories could mean a trade-off that managers make in favouring such categories at the expense of the representation of biodiversity features. In their comparison of Expert-driven and algorithm-based approaches to identifying priority areas for conservation, Cowling *et al.* (2003c) found that when evaluated against targets for vegetation units, the qualitative approach over-represented many habitats and under-represented some vulnerable ones. This highlights the importance of carefully considering which stakeholder groups to include in spatial conservation prioritisation (Strager & Rosenberger 2006) and the biases they may lead to.

In this study, the use of stakeholder input allowed for the consideration of the potential value of the Exit Areas which was considered in the quantitative analysis. None of the plantation areas were assessed for their potential as a Protected Area in the GRI (Holness *et al.* 2010), and were apparently under surveyed in all the Atlas datasets, but expert input allows for the incorporation of undocumented information and practical considerations of the area and the rehabilitation potential. These benefits were also identified by Cowling *et al.* (2003c), Ferrier & Wintle (2009) and Reed *et al.* (2009). In Systematic Conservation Planning, the inclusion of stakeholders is part of the planning process (Kukkala & Moilanen 2013) and their inclusion is well supported in the literature (Cowling *et al.* 2003c; Knight *et al.* 2006; Pomeroy & Douvere 2008; Reed *et al.* 2009; Gleason *et al.* 2010). This study thus supports the inclusion of stakeholders in the prioritisation process. Their inclusion can only be beneficial to the prioritisation of areas for biodiversity conservation by filling gaps in available data and including social and economic considerations into the prioritisation. A gap in the implementation of priority areas identified in conservation planning has previously been identified (Cowling *et al.* 2004), stemming from the failure of most assessments to focus on and to take active account of implementation issues (Cowling *et al.* 2004; Knight & Cowling 2007). In their review of eight South African conservation planning processes, Knight *et al.* (2006) identified that implementing organisations (i.e. conservation bodies) are key stakeholders as their inclusion can greatly enhance the probability of successful implementation and management of the priority areas. This provides a motivation for the inclusion of stakeholders, particularly from the management field, as operational considerations can be incorporated into planning to ensure the successful implantation of priority areas.

4.1 Recommendations

The findings in this study show that the choice of prioritisation approach will have an implication on the choice of areas for biodiversity conservation. This limitations identified in this study indicate that whichever approach is chosen, the effectiveness of each can be significantly improved upon by careful data and stakeholder selection. Quantitative methods can prove more effective by improving data quality and quantity (Roux *et al.* 2008; Robertson *et al.* 2010). Improved datasets can then be used to model species distributions for data poor regions. The incorporation of species distribution models into prioritisation has been widely applied (Cowling *et al.* 2003a; Moilanen *et al.* 2005; Kremen *et al.* 2008; Di Minin *et al.* 2013). Had species distribution modelling been included in this study it is believed that the results of the quantitative analysis could have been considerably improved upon. Thus it is recommended that such modelling be incorporated in all spatial prioritisations for biodiversity conservation. My results indicated that the choice of stakeholder groups and the number of participants will impact significantly on the prioritisation results. Qualitative methods can reduce the bias associated with stakeholder engagement through the careful selection of stakeholders, ensuring sufficient participation of the relevant stakeholders by applying a variety of stakeholder engagement methods (Reed 2008) and allowing for sufficient time to undertake such engagement processes.

Dichotomies between quantitative and qualitative methods are presented in this study, but rather than emphasising this, future prioritisation are recommended to integrate them. The effectiveness of conservation plans is likely to improve if expert knowledge and available data is better integrated in the prioritisation process.

For the Exit Areas in particular; although neither method yields priority areas throughout the entirety of the Area, the reality is that these areas have already been allocated to biodiversity conservation. A potential to provide value to the existing GRNP could exist. A next step could be to assess how best to maximise the potential of the areas to provide benefit to biodiversity conservation.

Future research opportunities also exist in investigating different methods of stakeholder engagement. All stakeholders were met with individually, making the method used in this study time consuming and costly. A comparison between the methods used in this study and alternative less costly methods would be beneficial to future conservation planning projects.

Although there were differences in the prioritisation of areas between approaches, neither approach indicated that the entire Exit Area is a priority area for biodiversity conservation. Previous planning within the study area by the GRI (Vromans *et al.* 2010) also indicated that 61% of the Exit Areas are not suitable for conservation land-uses. The Exit Strategy may contribute to the National Protected Area Expansion Strategy for South Africa (Government of South Africa 2010) and to achieving the targets for SANParks’ expansion strategy (South African National Parks 2008; Castley *et al.* 2009), yet these areas were allocated in an *ad hoc* manner; possibly contributing to the existing bias of Protected Areas within the CFR (Rouget *et al.* 2003b). Future allocations of land to Protected Status should no longer be such *ad hoc* allocations; although we might be reaching spatial expansion targets we may not be adequately protecting biodiversity to ensure its persistence.

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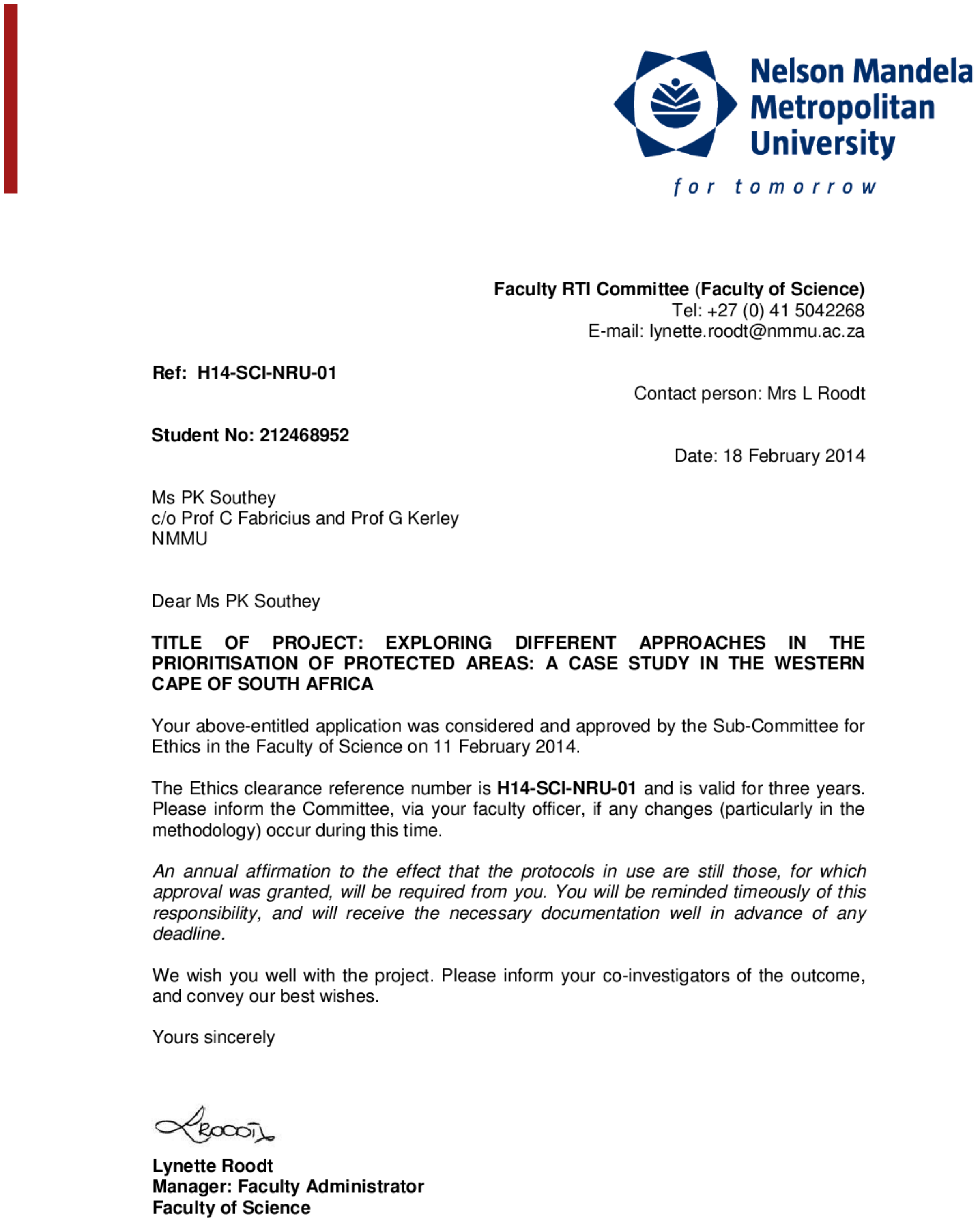
Appendix 1 – Ethics Approval



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Ref: H14-SCI-NRU-01

Contact person: Mrs L Roodt

Student No: 212468952

Date: 18 February 2014

Ms PK Southey
c/o Prof C Fabricius and Prof G Kerley
NMMU

Dear Ms PK Southey

TITLE OF PROJECT: EXPLORING DIFFERENT APPROACHES IN THE PRIORITISATION OF PROTECTED AREAS: A CASE STUDY IN THE WESTERN CAPE OF SOUTH AFRICA

Your above-entitled application was considered and approved by the Sub-Committee for Ethics in the Faculty of Science on 11 February 2014.

The Ethics clearance reference number is **H14-SCI-NRU-01** and is valid for three years. Please inform the Committee, via your faculty officer, if any changes (particularly in the methodology) occur during this time.

An annual affirmation to the effect that the protocols in use are still those, for which approval was granted, will be required from you. You will be reminded timeously of this responsibility, and will receive the necessary documentation well in advance of any deadline.

We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

LRoodt

Lynette Roodt
Manager: Faculty Administrator
Faculty of Science

Appendix 2 - Email communication to individuals identified to form part of the Specialist group:

Dear *(Identified expert)*

Please allow me to introduce myself, my name is Kate Southey and I am currently busy with my MSc at Nelson Mandela Metropolitan University. My project is focused on planning for the expansion of protected areas within the Garden Route.

To be more specific, this MSc aims to use the conversion of land from commercial forestry to conservation land uses to provide a comparison of two differing prioritisation techniques.

Included in my analysis are consultations with experts in various fields of biodiversity conservation within the study area. From an initial literature search, your previous and current publications within the region have identified you as part of this group. More detail on how you can participate will be provided at a later stage, however should you not wish to receive any further communication please do not hesitate to indicate so.

To further expand this group of experts I am looking for recommendations of individuals you are aware of who may have knowledge of some component of biodiversity within the area between George and Knysna, and knowledge of the important factors that influence that components distribution.

Thanking you in advance, and look forward to your recommendations.

Regards

Phillippa Kate Southey

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