A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

Use of Modified Threat Reduction Assessment to Estimate the Conservation Effectiveness of Protected Areas in Limpopo Province, South Africa

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Author’s declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by:
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for the degree of Master of Science and entitled: *Use of modified threat reduction assessment to estimate the conservation effectiveness of protected areas in Limpopo Province, South Africa.*
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Protected areas (PAs) are seen as the cornerstone of biodiversity conservation and their establishment is often used to demonstrate the success of conservation policies. However, despite the increase in number and extent of PAs, biodiversity loss trends remain largely unchanged. It has become apparent that simply establishing a PA is not enough and effective management is as equally important for achieving conservation success. The importance of monitoring and evaluation systems has been recognised by numerous institutions, triggering the development of different conservation performance assessment frameworks and tools; varying in their accuracy, scale and application. Modified Threat Reduction Assessment (MTRA) was selected to evaluate the management effectiveness of the Letaba Ranch Nature Reserve (LRNR), which serves as a buffer park of Kruger National Park (KNP), South Africa, and two bordering KNP sections (Mahlangeni, Phalaborwa). The aim of this research was to determine the nature of threats to biodiversity and their changes between 2013 and 2017 in all three sites. The research revealed 13 threats and determined negative TRA indices of -33.6% in LRNR and -13.6% in the Phalaborwa section, and a positive +13.2% reduction in threats in Mahlangeni. Combined with the results of geospatial visualisation of changes in threats, the research indicates that LRNR is not sufficiently meeting the objective of supporting the ecological integrity of KNP, but further exposes it to threats.

Keywords: Modified Threat Reduction Assessment (MTRA), protected area, biodiversity threats, management effectiveness, buffer zone, Kruger National Park, Letaba Ranch Nature Reserve, geospatial representation of threats.

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Table of Contents

List of Tables

List of Figures

List of abbreviations

CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMPA	Collaborative Management of Protected Areas
DEA	Department of Environmental Affairs
DRDLR	Department of Rural Development and Land Reform
ECI	Environemental Crime Investigation Unit
FMU	Fire management unit
GEF	Global Environmental Facility
GIS	Geographic Information System
GLTCA	Greater Limpopo Transfrontier Conservation Area
GLTP	Greater Limpopo Transfrontier Park
IAS	Invasive alien species
ICCA	Indigenous/Community Conserved Area
IDP	Integrated Development Plan
IUCN	International Union for Conservation of Nature
K2C	Kruger to Canyon Biosphere Reserve
KNP	Kruger National Park
LEDET	Limpopo: Department for Economic Development, Environment and Tourism
LRNR	Letaba Ranch Nature Reserve
MEE	Management Effectiveness Evaluation
METT	Management Effectiveness Tracking Tool
MPA	Marine Protected Area
MRNR	Mthimkhulu Nature Reserve
MTRA	Modified Threat Reduction Assessment
NGO	Non-governmental organisation
NBA	National Biodiversity Assessment
NBSAP	National Biodiversity Strategy and Action Plan
NEMA	National Environmental Management Act
NEM: BA	National Environmental Management: Biodiversity Act
NEM: PAA	National Environmental Management: Protected Areas Act
PA	Protected Area
PAME	Protected Area Management Effectiveness
PoWPA	Programme of Work on Protected Areas
RAPPAM	Rapid Assessment and Prioritisation of Protected Area Management
RSA	Republic of South Africa
SAM	Strategic adaptive management
SANBI	South African National Biodiversity Institute
SANF	South African Nature Foundation

SANDF	South African National Defence Force
SANParks	South African National Parks
TRA	Threat Reduction Assessment
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WCPA	World Commission on Protected Areas
WDPA	World Database of Protected Areas
WWF	World Wildlife Fund

1. Introduction

1.1 Background

As we are entering what many scientists call the Earth's six mass extinction (Thomas *et al.* 2004; Wake and Vredenburg 2008; Pimm *et al.* 2014; McCallum 2015), the importance of biodiversity conservation is more apparent than ever. Perhaps the most efficient conservation tool is the establishment of protected areas (PAs) which have a role in lessening human impact and protecting biodiversity within their borders (Dudley 2008). However, despite the increased number and the extent of established PAs over recent decades (Chape *et al.* 2005), biodiversity loss trends are still increasing and anthropogenic impacts continue (Bertzky *et al.* 2012). This has led to the growing recognition that the effectiveness of protected areas in conserving biodiversity is not solely dependent on their size, number and physical characteristics (Leverington *et al.* 2010) but that their management is as equally important (IUCN-WCPA 2009). It has become apparent that there is a need for management effectiveness evaluation (MEE) which can help PA management staff to assess their current management strategies, identify their shortcoming and successes so they can modify interventions and more efficiently allocate resources (Salafsky and Margoluis 1999). As a crucial part of every evaluation is monitoring, there has been a debate on which indicators are best to be used for monitoring conservation (Margules and Pressey 2000; Margoluis and Salafsky 2001). Generally, there are *biological indicators* and *management*, the latter often being less costly and more practical to use (Margoluis and Salafsky 2001, Tucker 2005; Margoluis 2009). Protected Area Management Effectiveness (PAME) schemes were developed as a way of examining PA performance using management indicators (Hockings and Phillips 1999). One PAME evaluation tool, namely the Threat Reduction Assessment (TRA) focuses on the direct threats to biodiversity and conservation (Salafsky and Margoluis 1991).

The Republic of South Africa (RSA) is one of the leading countries in the world when it comes to conservation efforts (DEA 2015). It is listed as one of 17 megadiverse countries thanks to its extremely rich biodiversity and level of endemism (Driver *et al.* 2011). Given the number of pressures to RSA's ecosystems (Driver *et al.* 2011), it has developed a strong national and international legislative commitment to conservation, with many innovative conservation strategies put in place (Child 2012; DEA 2015). It is home to one of the largest PAs in the world, the Kruger National Park (KNP) and its adjacent reserves, including the Letaba Ranch Nature Reserve (LRNR), which are managed by two different authorities: South African National Parks (SANParks) and Limpopo: Department for Economic Development, Environment and Tourism.

1.2 Justification for research

With the recent recognition of the importance of buffer areas in South African conservation policy, an increasing number of so-called 'buffer parks' are being established around protected areas, specifically national parks. One of these buffer parks is the LRNR adjacent to KNP, a world renowned protected area which has been managed for conservation for over 100 years. As the fence between the two protected areas has been removed, there is a clear need for evaluating management effectiveness in the LRNR that could indicate if it is meeting the objective of supporting the ecological integrity of KNP, or further exposing it to threats.

By combining records review, informal interviews, MTRA approach and geospatial modelling, this research evaluates the management effectiveness of three sites, specifically focusing on the nature and the source of the threats, as well as mitigation interventions in place.

1.3 Aim and objectives

This research aims at *identifying the nature of threats to biodiversity in the Letaba Ranch Nature Reserve and in selected sections of Kruger National Park.*

The following objectives were set to assist in achieving the aim:

1. Reviewing the available protected area management effectiveness evaluation tools and selecting the most suitable one;
2. Administering the tool in three different sites;
3. Spatially describing the threats based on the geospatial data;
4. Comparing the threats across all three sites, analyse their source and management interventions in place.

1.4 Research problem

The research will attempt to answer the following:

To what degree have threats to biodiversity in the Letaba Ranch Nature Reserve been mitigated from 2013 to 2017, compared to adjacent sections of Kruger National Park?

1.5 Research contribution

This research will contribute to the PAME field by validating the application and use of MTRA, while providing an invaluable insight into the management challenges in the study area. From the practical perspective, the research will benefit greatly management teams from KNP and LRNR, as it will (i) assist in identifying threats to biodiversity and their mitigation, (ii) introduce a methodological tool which may be incorporated into management monitoring, and (iii) assist management teams to reflect on their management and modify interventions accordingly.

1.6 Organisational structure

This thesis is organised around five main chapters. The first chapter provides introductory information on the research background, identifies the aim and the objectives of the study and the research question it will attempt to answer. Chapter two provides a synthesis of an extensive review of literature concerning the main concepts used in the research and the local context in which the research was undertaken. The third chapter includes the methodology utilised for data collection and analyses, as well as study limitations and how they were minimised. The fourth chapter will first provide the summary of both MTRA and geospatial modelling results; and also discuss these results and compare them across three assessed sites with a brief overview of relevant additional findings. The fifth chapter will conclude the thesis, summarising research findings and providing recommendations for future research.

2. Literature Review

2.1 Introduction

This chapter provides justification for the topic chosen and explanation of key concepts used in the study, such as biodiversity, biodiversity threats and protected areas. It further explains protected area management effectiveness (PAME) and its evaluation, including reasoning behind utilising the Modified Threat Reduction Assessment (MTRA) for this research. The second part will focus on the study area in order to justify the choice of the area and contextualise the research.

2.2 Biodiversity conservation

2.2.1 Biodiversity

Biological diversity, or biodiversity, is a relatively recent term that came into wide use after the American National Forum on BioDiversity in 1986 (Wilson 1997) but is now becoming increasingly used in international and national policies, environmental management and scientific literature. The concept of biodiversity is somewhat uncertain due to a large number of different definitions. DeLong (1996) reviewed 85 such definitions; some authors consider it to be interchangeable with species richness (Heywood 1998), others synonymous with species diversity (Bond and Chase 2002) while many advocate for defining it as the "full variety of life on Earth" (Takacs 1996). Perhaps the most overarching and globally accepted definition is found in Article 2 of the Convention of Biological Diversity (CBD), signed in Rio in 1992, i.e.

> *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (CBD 1992).

The convention further recognises its: "*ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values' and biodiversity's importance 'for* *evolution and maintaining life sustaining systems of the biosphere"* (CBD 1992). Some authors believe it is incomplete, as it does not clearly take into account the biodiversity from the past and all living forms that are now extinct (Gaston and Spicer 2004). Nevertheless, what it is important is that the definition of biodiversity evolved over the years from focusing only on purely quantitative features to including qualitative elements; it has been increasingly recognised that it is not the number of different genes, species and ecosystems what constitutes biodiversity, but also complexities of habitat (e.g. area and condition), as well as ecosystem functioning (Noss 1990).

The CBD was established as a global response to the increasingly alarming biodiversity crisis. Human impact on Earth goes back in time long before the industrial revolution (Steffen *et al.* 2011) and has been linked with major megafauna extinctions (Lorenzen *et al.* 2011) and habitat loss (Ellis *et al.* 2013). However, increasing human population and technological development over the last century have caused acute and rapid environmental changes (UNEP 2012), with more than 75% of Earth's land surface being impacted by humans today (Ellis *et al.* 2010).

Declines in biodiversity are associated with changes that are reducing or homogenising the biological diversity at many levels, from genes to habitats and ecosystems (Gaston and Spicer 2004). Although biodiversity loss takes many forms, species extinction is irreversible and is considered the most severe form and many authors believe that we are entering or are witnessing the sixth mass extinction (Thomas *et al.* 2004; Wake and Vredenburg 2008; Pimm *et al.* 2014; McCallum 2015), a hypothesis strengthened by studies showing that the current extinction rates are a thousand (Pimm *et al.* 2014) to several thousands (Ceballos *et al.* 2015) times the background rate. It is important to note that the current extinction crisis comprises both species and population losses. The extinction of local populations reduces taxonomic, genetic and functional diversity of ecosystems, and further contributes to global species losses (Gaston and Spicer 2004).

The CBD set a global 2010 Biodiversity Target which was to significantly reduce the degree of biodiversity loss by 2010. Unfortunately, the target failed to be met (CBD 2010b) and it is now left to be seen if the goals defined in the newly adopted Strategic Plan for Biodiversity 2010-2020, so called Aichi Targets, will be achieved and anthropogenic threats will be mitigated (CBD 2010a).

2.2.2 Biodiversity Threats

For the purpose of this research and utilisation of proposed methods (see 3.4.1.), it is necessary to define what a biodiversity threat is. Depending on the organisation, scope and the scale of the project, specific frameworks have been developed to describe the relationship between threats and biodiversity with varied terminologies (four ways are illustrated in Figure 1) (EPA 1998; TNC 2000; Ervin 2003; Salafsky *et al.* 2002). Similarly, there is a vast discrepancy in the taxonomy of naming specific threats, which is additionally hindering global conservation efforts. The lack of common terms creates problems "in planning and setting of priorities, in designing projects and developing effective strategies, in measuring the overall conservation status and effectiveness and problems in learning" (Salafsky *et al.* 2003).

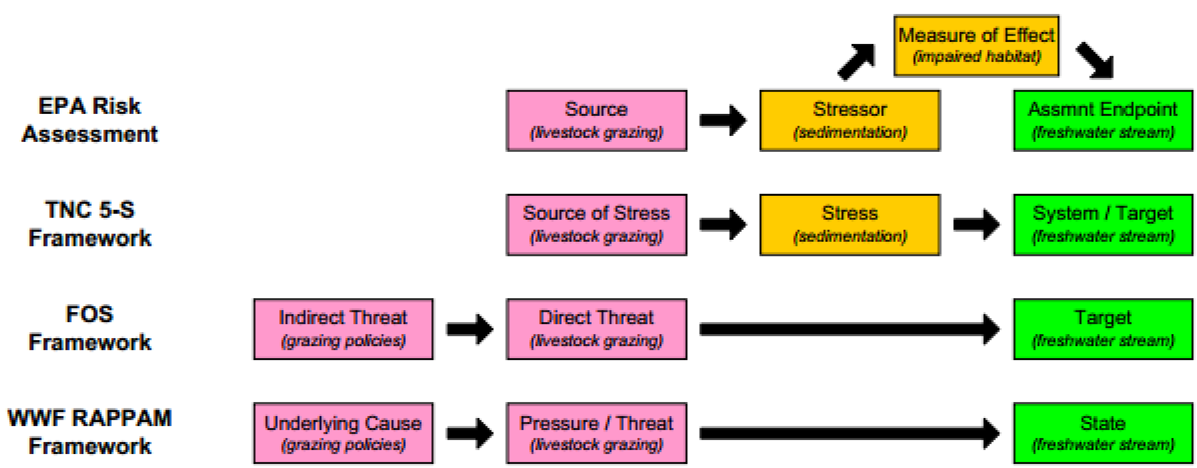

Figure 1. Four frameworks developed to describe the relationship between threats and biodiversity. Source: Salafsky *et al.* 2003.

As a result, there is a growing need in conservation sciences for a standardised language used when talking about threats, stressors and conservation actions (Salafsky *et al.* 2008). Salafsky *et al.* (2008) attempted to create a standardised lexicon of threats and proposed a common definition of the threats. In the unified classification, threats are divided into two groups and defined as:

1. Direct threats – "The proximate human activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity targets". They can be both internal and external.
2. Contributing factors – "The ultimate factors, usually social, economic, political, institutional, or cultural, that enable or otherwise add to the occurrence or persistence of proximate direct threats". These factors are further subdivided into indirect threats, or factors with negative effect, and opportunities, factors with positive effects.

The lexicon has been adopted by IUCN and is now widely used in conservation. The definition of direct threats and the threat lexicon will be used for the purpose of this research while the contributing factors will not be considered as they are out of the scope of the study.

2.2.3 Protected Areas and their management

Perhaps the most efficient tool that came as a response to the biodiversity crisis are protected areas (PAs). They are considered to be the cornerstone of biodiversity conservation (Ervin *et al.* 2010) and are included in the CBD as a key strategy for biodiversity conservation: by 2020, governments committed to conserve 17% of the terrestrial and inland water and 10% of coastal and marine areas (CBD 2010a).

Although the modern form of PAs has developed recently, the idea of conserving natural areas to protect their value is not a recent phenomenon. Historically, humans were setting aside areas for different cultural, religious or resource use reasons. In India, areas designated for the protection of natural resources track back to over 2000 years ago while a thousand years ago in Europe pieces of land were established as royal hunting grounds (Eagles *et al.* 2002). During the 19th century, the human impact on the environment has become apparent which led to the creation of the first national parks and nature reserves; the Yellowstone National Park established in the USA in 1872 is considered to be the beginning of a "modern era of protected areas" (Chape *et al.* 2005). During the 20th century, the concept spread all around the world and more and more PAs were established. Today, there are 202,467 designated terrestrial and inland water PAs, covering 14.7% of the land surface, and 14,688 Marine Protected Areas (MPA), covering 4.12% of the global ocean and 10.2% of coastal and marine areas under national jurisdiction (UNEP-WCMC and IUCN 2016).

As the number of PAs increased dramatically in the last century, so did the number of terms and definitions, as each country developed their own approach to the management of PAs. Similarly, global and regional international conventions also use different terminology (e.g. World Heritage Sites, Ramsar Sites, Natura 2000) (Dudley 2008). Today, more than 1000 different terms exist around the world to describe what constitutes a PA (Chape *et al.* 2005), but it is generally recognised that their purpose is to lessen human impact and maintain and/or enhance biodiversity, habitat and ecosystem processes within their borders. The most widely accepted definition has been created by IUCN and states the following:

> "*A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values.*" (Dudley 2008)

IUCN has introduced a universal categories system to further help the standardisation standardise efforts and establish a universal language for describing PAs (Table 1). The system recognises six different categories based on their main management objective, distinguishing features and level of human presence within the PA boundary (Dudley 2008). Not all countries use this system, and there are many PAs that remain uncategorised or put into multiple categories. However, it is still the most globally accepted system, adopted by governments, various NGOs and organisations such as UN and CBD (Dudley 2008).

Table 1. International Union for Conservation of Nature protected area classification.

Category	Name	Description
Ia	Strict Nature Reserve	Strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Can serve as indispensable reference areas for scientific research and monitoring.
Ib	Wilderness Area	Usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.
II	National Park	Large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.
III	Natural Monument or Feature	Are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.
IV	Habitat/Species Management Area	Aim to protect particular species or habitats and management reflects this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.
V	Protected Landscape/Seascape	Area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.
VI	Protected Area with sustainable use of natural resources	Conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

Source: Dudley 2008.

To achieve conservation of biodiversity within their boundaries, PAs require specific management actions and interventions, which are usually set out through a management planning process. According to Tucker (2005), management plans are most effective if the assessment of the status of biodiversity is done and the management objectives are based on it. A management plan should then be implemented and regularly monitored, in order to determine if the management strategies are succeeding and the objectives are being met (Tucker 2005). Ideally, monitoring results are then evaluated and incorporated into the management plan which is updated with each cycle. This cycle constitutes so-called adaptive management, an approach based on the assumption that management is essentially an experimental process which is being continuously adapted and improved by 'learning by doing' (Margules and Pressey 2000; Salafsky et al. 2002). This is best described by Roux and Foxroft (2011), who state that "when adaptive management is practiced, policies become hypotheses and management actions become the experiments to test those hypotheses". The adaptive management approach has been widely acclaimed in conservation planning, as it acknowledges that ecological systems are dynamic and that our knowledge about them is incomplete (Salafsky et al. 2002; Tucker et al. 2005). Participation of key stakeholders in management processes and decision-making, through a participatory approach, is also encouraged as part of adaptive management (Tucker et al. 2005). Over the years, there has been a paradigm shift in conservation, ranging from the concept of 'fortress conservation' (Brockington 2002) to today's, increasingly valued, involvement of local communities and other key stakeholders in PA management (Kothari 2004). There are two general streams in which participatory conservation is achieved: 1. by including indigenous and local communities in decision-making, through Collaborative Management of Protected Areas (CMPAs) and 2. by having PAs managed primarily by local people, through Indigenous/Community Conserved Areas (ICCAs) (Kothari 2004). These came into being with the rising concern for the rights of indigenous and rural populations, but also as a way to ensure the support, sustainability and effectiveness of PA management (Kothari 2004). In addition to participatory and adaptive approaches to PA management, which are widely adopted nowadays, there are other management systems that might may be appropriate for certain PAs, depending on the local context (Matar 2009).

Rangers play a crucial role in management implementation and law enforcement in most of the PAs, especially in national parks. Although rangers' duties are country-and park-specific, their work generally consists of patrolling park grounds, ensuring that visitors are following park safety regulations and enforce the law in case of any misbehavior. In some PAs, rangers also participate in tourist activities, providing guided tours and interacting with the visitors.

2.2.4 Protected Areas Management Effectiveness (PAME)

Despite some examples of successful conservation efforts (Sodhi *et al.* 2011), and the increased area and number of established PAs over recent decades (Chape *et al.* 2005), overall biodiversity and habitat loss trends are still increasing and anthropogenic impacts are not ceasing (Bertzky *et al.* 2012). In some cases, biodiversity loss is not halted even within the PAs (Craigie *et al.* 2010; Laurance *et al.* 2012; Francoso *et al.* 2015).

Previously, PAs have been evaluated based on their location and coverage, focusing on species (Rodrigues *et al.* 2004), threatened species (Watson *et al.* 2010) and ecoregion and biome representativeness (Jenkins and Joppa 2009). However, it is becoming increasingly apparent that the effectiveness of protected areas in conserving biodiversity is not solely dependent on their number, size and other physical features (Leverington *et al*. 2010) but that their management is as equally important (IUCN-WCPA 2009). The importance of PA management effectiveness (PAME) is also recognised in Aichi target 11, namely:

> "*By 2020, at least 17 per cent of terrestrial and inland water, and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through* ***effectively and equitably managed****, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes"* (CBD 2010a).

In parallel, there is an increased need for management effectiveness evaluation (MEE), translated into conservation policy; CBD Conference of the Parties (COP) 10 Decision X/31 which calls for an obligatory requirement of:

> *"…Parties to…expand and institutionalise management effectiveness assessments to work towards assessing 60 per cent of the total area of protected areas by 2015 using various national and regional tools, and report the results into the global database on management effectiveness"* (CBD 2010c).

Evaluating PAME can be difficult, as the reasons behind their underperformance may result from different factors and differ on a case to case basis. However, it is becoming increasingly important to conduct MEEs, as the need for accountability, transparency and efficient strategies is increasing together with the number of PAs (Hockings *et al.* 2006).

The rising concern for the rights of indigenous and rural populations has highlighted the need to demonstrate the benefits of PAs and the extent to which they contribute or take from community well-being (Timko and Satterfield 2008). Moreover, MEE serves as a valuable source for linking changes in biodiversity to particular interventions so that park managers can allocate resources, modify their interventions and learn from both negative and positive experiences (Salafsky and Margoluis 1999) which is key for adaptive management of PAs (Leverington *et al.* 2010). Lastly, it affords an opportunity for PA management to demonstrate successes and shortcomings to their staff but also to outside institutions, thus justifying targeted funding opportunities and community awareness that would benefit the PA (Salafsky and Margoluis 1999).

Monitoring is a crucial component of any evaluation, needed for detecting changes and tracking progress towards management objectives (Tucker 2005). There are generally two types of indicators used - biological and management - and there is ongoing debate on which are best suited for monitoring conservation efforts (Margules and Pressey 2000; Margoluis and Salafsky 2001). Biological indicators are often found to be costly and difficult to implement, as collection and interpretation of the data requires trained personnel and special equipment (Margoluis and Salafsky 2001; Hockings 2003; Anthony 2008). This is particularly challenging in developing countries. Secondly, biological approaches are problematic when it comes to data: they require baseline data to compare findings, which is often lacking (Margoluis and Salafsky 2001), or there is too much inessential data collected for answering management questions (Tucker 2005). Furthermore, biological parameters often change slowly over time, with significant lag times between human activity and the effects it may have on ecosystems, making these indicators too insensitive to detect change when assessing short-term projects (Margoluis *et al.* 2009). Frequent, natural fluctuations in e.g. species population can further skew results and misrepresent impacts of management interventions (Margoluis and Salafsky 2001). However, biological indicators are important for the prioritisation of conservation actions, as they provide information at a finer scale e.g. population size of an endangered species (Rao *et al.*2007).

Protected Area Management Effectiveness (PAME) schemes were developed as a cost-effective way of examining PA performance using management indicators (Hockings and Phillips 1999). Although there are many approaches and tools used to evaluate management effectiveness, no

PAME evaluation system can be applied worldwide as the aims and circumstances under which PAME is conducted are very diverse. In fact, there are more than 50 different MEE methodologies (Leverington *et al.* 2010), most of which are modified standard approaches adapted to specific local conditions (Hockings 2003). To help synchronise the efforts around the world, IUCN has developed guidelines for MEE (Hockings *et al.* 2006), while Leverington *et al.* (2010) attempted to develop tools that allow comparison across schemes. Some of the most common frameworks and tools are described below.

The World Commission on Protected Areas (WCPA) Framework was developed to provide guidance for developing more adaptive assessment tools in each PA and set standards for reporting (Hockings *et al.* 2000). It is based on an idea that every protected area goes through the same stages in order to become a fully-functioning PA (Hockings and Phillips 1999). The framework is built on a PA Management and Assessment cycle that includes six different elements. It starts first with focusing on the current status of the PA and knowing the *context* of threat and values present within. Then it goes through *planning* which results in *inputs* or allocation of resources that further lead to specific management *processes.* Those actions achieve certain results or management *outputs* and can be translated into *outcomes* that have or have not achieved the objectives set (Hockings *et al.* 2006). The framework also emphasises the importance of basing management processes on "clear, measurable and outcome-based" objectives in order to facilitate monitoring and achieve better results (Tucker 2005). This framework has been used worldwide in various organisations and institutions, and has served as an important foundation for the development of other tools, such as RAPPAM and METT (Anthony 2014).

Based on the WCPA Framework, World Wildlife Fund (WWF) created a Rapid Assessment and Prioritisation of Protected Area Management (RAPPAM) methodology that is being used for comparison between multiple PAs within a PA system, with the main aim of prioritising allocation of the resources based on the management needs (Ervin 2003). The tool is applied through a Rapid Assessment Questionnaire that includes all the WCPA Framework elements, but has an increased focus on the *context* and management *outputs.* The most important results of RAPPAM, usually applied through a workshop format, consist of the list of the most frequent threats (both past and potentially occurring in the future), management strengths and shortcomings and ranking of PAs according to their vulnerability (Anthony 2014). The main disadvantage of RAPPAM is that it usually lacks in-depth study of one particular site, since it is designed to prioritise PAs across whole PA systems (Ervin 2003). This particularly limits its ability to contribute to adaptive management guidance (Anthony 2014). Furthermore, as threats are assessed through a scoring system, there is a risk of result bias due to the subjectivity of participants (Ervin 2003). This could be minimised by conducting more frequent workshops and including a wider range of stakeholders, although this could make the assessment more complicated and time-consuming, depending on the context, which could be considered as a limitation (Anthony 2014). Nonetheless, RAPPAM has been widely used, with assessments done in >1600 PAs across 53 countries (Leverington *et al.* 2010).

Another tool developed by WWF and published in 2003 is the Management Effectiveness Tracking Tool (METT), a simple and easy tool originally created to monitor progress in forest PAs and designed to complement other more detailed assessments. Over the years, it has been adopted by many organisations, modified to be applicable in other types of PAs and updated to a version released in 2007 (WWF 2007). The assessment is based on a scorecard questionnaire that covers the WCPA Framework management elements, but highlights the importance of *context, planning, inputs* and *processes.* The METT assessment is comprised of two parts: datasheets, with basic information about the site, threat identification and threat ranking according to their impact on the PA(s), and assessment form, which is comprised of 30 questions that are given a score from 0 (poor) to 3 (excellent). The main limitation of the METT tool is that, since it is designed to measure progress of only one site, it does not allow comparison across sites (WWF 2007). Moreover, it does not provide a detailed evaluation of the outcomes, but more a rapid and vague evaluation of management interventions (WWF 2007). Lastly, although quantitative in nature, which might be considered an advantage, the tool's scoring system assumes that all 30 questions weigh the same despite the fact that some portions of the questionnaire might be more important than others (e.g. state of biodiversity) (WWF 2007; Anthony 2014). Even so, the tool has been applied >1300 times in >1100 PAs (Leverington *et al.* 2010) and is required by the World Bank/WWF Forest Alliance and Global Environment Facility (GEF) for all PA projects that are funded by these organisations (Anthony 2014).

A third tool is the Threat Reduction Assessment (TRA), developed by Salafsky and Margoluis (1999) that measures management effectiveness indirectly by concentrating on changes in direct biodiversity threats within a PA. Even though both RAPPAM and METT both assess threats and the PA vulnerability, TRA presents a more focused and detailed approach on direct threats to biodiversity and conservation. It is used to measure outcomes and identify effective management strategies, while overcoming the limitations of using biological indicators (Salafsky and Margoluis 1999).

The TRA approach has many advantages; it is a simple, practical and cost-effective PAME tool. It creates one unitless quantitative result (TRA Index) which is easy to understand and compare across sites. Moreover, it is less time-consuming than other approaches, as it can be achieved through only one session with the most knowledgeable park managers and, as it is based on knowledge that park managers already have, it is very cost effective (Loughney 2013). Compared to methods measuring changes in biological parameters, TRA is more sensitive to changes over short periods of time and reflects them throughout the whole area (Salafsky and Margoluis 1999; Anthony 2008). TRAs can also be conducted retrospectively and even where baseline data is scarce (Salafsky and Margoluis 1999). Finally, perhaps the most important strength for this particular research, is its comparability across sites (Anthony 2008).

However, there are a number of weaknesses in TRAs, one being that they are susceptible to bias, especially when estimating the percentage of the threat reduction and ranking of threats as these rely on subjectivity of participants (Salafsky and Margoluis 1999; Persha and Rodgers 2002; Tucker 2005). Secondly, TRAs do not address threats that have worsened or newly appeared. This weakness has been alleviated by Anthony (2008), who developed a second version of the method, Modified Threat Reduction Tool (MTRA), by including negative scoring for worsening and emerging threats. MTRAs have been tested and the validity of the method has been demonstrated through studies in South Africa, Lebanon, Ghana, Mongolia, Ukraine and Grenada (Anthony 2008; Matar 2009; Ganbaatar 2011; Anderson 2012; Kovalenko 2012; Loughney 2013).

Using MTRA can make the identification and representation of the state of PA more accurate, therefore this version was used for this research. Justification and methodological steps will be discussed in detail in Chapter 3.

2.3 Study area

2.3.1 South Africa

South Africa, officially the Republic of South Africa (RSA), is a country located at the southern tip of the African continent, covering a total land surface area of 1 221 037 km^2 (UN 2017). It is bounded by the Indian and South Atlantic Oceans on the south, Namibia, Botswana and Zimbabwe on the north, and Swaziland and Mozambique on the east, while it is completely surrounding the Kingdom of Lesotho. It has a population of approximately 55 million people, making it the 24th most populous country in the world (UN 2017). It is very diverse country in terms of ethnicities, cultures, languages, socio-economic conditions and biodiversity.

2.3.2 South Africa's Biodiversity

RSA is listed by Conservation International as one of the 17 megadiverse countries of the world, due to its highly diverse ecosystems, species richness and endemism (Driver *et al.* 2011). The terrestrial biodiversity of RSA can be classified into nine biomes: Albany thicket, desert, forest, fynbos, grassland, Indian Ocean coastal belt, Nama karoo, savanna and succulent Karoo, with more than 440 different vegetation types (Mucina and Rutherford 2006). Coastal marine habitats and estuaries are divided into three biogeographical zones: subtropical, warm temperate and cool temperate zone, and together with the terrestrial ecosystems, hold a variety of different habitats and landscapes. Although occupying only 2% of the planet's land surface area, the country has 95,000 species and contributes to the global biodiversity with 6% of plant, 5% of reptile, 8% of bird and 6% of all mammal species, with many being only found within South Africa. Its coastline is home to 270 out of 325 world's marine fish families and 15% of all known coastal marine species (Driver *et al* 2011). RSA's species richness and level of endemism is further reflected in the fact that it has three of 36 global biodiversity hotspots: the Succulent Karoo, shared with Namibia; Maputaland Pondoland-Albany hotspot, partially found in Mozambique and Swaziland; and the Cape Floristic region, home to the smallest and richest floral kingdom, where more than 9000 plant species are found within an area of only 9000 km2 (Meadows 2000; Driver *et al.* 2011).

2.3.3 Main pressures and the status of biodiversity in RSA

The first National Biodiversity Assessment (NBI) of RSA biodiversity was conducted in 2004, followed by a second one in 2011. Both were led by South African National Biodiversity Institute (SANBI), in cooperation with numerous organisations, stakeholders, scientific institutions and biodiversity managers. The assessment included the state of the RSA's biodiversity and key pressures across terrestrial, freshwater, estuarine and marine environments. By giving a brief overview of the results of this assessment this section aims to illustrate the key pressures and the scale of its impact on the ecosystems and species in RSA.

The primary threat to biodiversity in RSA is the loss and degradation of natural habitats. Drivers vary across the country, but at a national level, land conversion for crop cultivation, forest plantations, mining and urban development are to blame for a loss of over 18% of RSA's terrestrial ecosystems during the last century (Driver *et al.* 2011). The rates of habitat loss in provinces of Gauteng, KwaZulu-Natal and North West Province are the highest and according to the NBI 2011, there will be few natural habitats left outside PAs by 2050 if the current trend of land conversion continues (Driver *et al.* 2011). In addition, overgrazing, invasive plant species and frequent unregulated fires lead to habitat degradation, which is a serious problem in arid areas in the western parts of the country. There is no national assessment of the extent of habitat degradation, but local studies, such as in the Little Karoo region of the Western Cape, have shown that 15% of the area was severely and 37% moderately degraded (Thompson *et al.* 2005). When it comes to individual species, especially species that need large ranges, the problem is not only the pure loss of area, but also concomitant degradation of remaining habitat. In addition, illegal hunting of animal species, particularly rhino poaching, presents an immense problem in RSA. RSA is home to more than three-quarters of the world's rhino population, with the majority being located in KNP (DEA

2013). The species is targeted for its horn, which is believed to have medicinal properties and the highest demand comes from Vietnam, where the horn can be sold for up to USD$65,000-100,000 per kilogram (DEA 2013). In 2016, a total of 1054 rhinos were poached in RSA, 662 of which were killed in KNP (DEA 2017).

The abovementioned human activities, together with dam construction, water extraction for irrigation, pollution, poor catchment management and destruction of riparian vegetation are threating RSA's freshwater and wetland ecosystems. Large main rivers are generally more affected than tributaries by flow alteration, which is considered to be the greatest threat, and by excessive pollution from agricultural, domestic and industrial sources (Driver *et al.* 2011). Therefore, 57% of the river ecosystems in RSA are considered threatened, with 25% being critically endangered, 19% endangered and 13% vulnerable. If only main rivers are assessed, without tributaries that are likely to be in a better condition, 65% are threatened and 45% are critically endangered (Driver *et al.* 2011). It is not surprising that most of the threatened rivers are located in the lowlands, where intensive agriculture and urban development takes place, as well as where the impacts on the river throughout its flow from the source to the sea accumulate.

Concerning wetlands, their highly productive land is often drained and converted for crop cultivation or stock farming, a process that was strongly encouraged by agricultural policies in RSA until the 1980s (Driver *et al.* 2011). In some parts of the country, wetland ecosystems are further threatened by mining for coal deposits stored beneath them. Although the government's approach has changed and the value of wetlands is more widely recognised today, estimates are that 50% of the historical wetland occurrence has been irreversibly lost and it is still considered the most threatened ecosystem in RSA, with 62% of remaining wetlands being threatened: an alarming 45% critically endangered, 12% endangered and 5% considered vulnerable (Driver *et al.*

2011). However, wetland ecosystems show remarkable resilience, more than any other ecosystem so as long as they are not entirely converted and lost, they can be rehabilitated to a certain extent.

River modifications also greatly impact the estuarine environments, reducing the amount and altering the quality of the freshwater reaching the estuary and its ecological condition. Approximately 40% of the flow from RSA's 20 largest river catchments does not reach their given estuaries, which resulted in the first-ever closure of two estuaries in 2010: the Kobonqaba in Eastern Cape and Uilkraals in the Western Cape (Driver *et al.* 2011). In addition, development close to the estuaries, over-fishing, pollution, invasive alien species (IAS) and climate change all cumulatively affect the estuary ecosystems in RSA, of which 43% are threatened (Driver *et al.* 2011).

Lastly, there are a number of pressures on marine and coastal ecosystems in RSA. They can be divided into coastal and inshore ecosystems, which are more accessible and thus more affected by humans, and offshore ecosystems. Due to the intensification of coastal development in RSA over the last 20 years, this is regarded as the primary threat to coastal and inshore ecosystems (Driver *et al.* 2011). Today, more than 17% of the entire RSA coastline has some sort of development within 100 m from the shoreline and, together with other pressures like invasive species, made approximately 58% of the coastal ecosystems threatened (Driver *et al.* 2011). Offshore systems are predominantly stressed by over-exploitation of marine resources, including commercial, recreational and illegal fishing, and mining for diamonds, oil and gas (Driver *et al.* 2011). Additionally, RSA has some numerous ports and a substantial ship traffic. Thousands of ships travel around Cape Point yearly, posing a serious risk of oil spilling and introduction of invasive species through ballast water discharge and hull fouling. The risk is further amplified by the lack of implementation of Ballast Water Convention, which RSA is a signatory of, and the fact that RSA still has not banned hull cleaning at sea (Driver *et al.* 2011).

Knowing the scale and the number of different pressures on RSA ecosystems, it is not surprising that many species, as "building blocks of ecosystems" are also threatened (Driver *et al.* 2011). RSA has a committed Threatened Species Programme and is considered to be the world leader in Red Listing, due to the fact that it has assessed a much wider range of taxonomic groups than many other countries. Furthermore, it is the first megadiverse country to have assessed its whole flora (Raimondo *et al.* 2009). Most recent assessments completed in 2010 for amphibians, 2011 for plants and reptiles 2015 for birds and 2016 for mammals.

2.3.4 Conservation in RSA

2.3.4.1 Legislative background

RSA has a number of national policies and legislative frameworks tackling conservation and management of natural resources and biodiversity. The basic framework for environmental governance is outlined in South Africa's Constitution Act (Act 108 of 1996), which recognises "*the right to an environment that is not harmful to health and wellbeing*" and distributes tasks to different governmental institutions while calling for cooperation between all government domains. Specifically concerning biodiversity, this has been translated into the National Environmental Management Act (NEMA) (Act 107 of 1998) and later into the NEM: Biodiversity Act (NEM: BA) (Act 10 of 2004) which present "main legislative frameworks for the management of biodiversity" (DEA 2005). The National Environmental Management: Protected Areas Act of 2004 (NEM: PAA) is the main legislative document concerning the protection of RSA's biodiversity and conservation. In coordination with the Biodiversity Act, RSA published a National Biodiversity Framework in 2009, as a way of aligning the conservation efforts across institutions. One of the base elements of the framework is the National Protected Area Expansion Strategy, which outlines the targets for PA expansion, identifies priority areas and recommends the mechanisms for achieving it.

Further, in line with the international requirements set out by CBD, RSA has developed a National Biodiversity Strategy and Action Plan (NBSAP) in 2005 (DEAT 2005) which was revised and updated recently for a period from 2015 to 2025 (DEA 2015). The NBSAP provides a "integrated, coherent national strategy for the conservation, management and sustainable use of biodiversity and specifically, outlines how contracting parties will fulfil the objectives of the Convention" (DEA 2015). In addition to national legislation, RSA is a signatory of numerous international conventions, treaties and protocols that shape its national environmental policies and legislation. The main ones, together with other relevant policies and legislation are provided in Table 2. Given their number and variety, it is clear that RSA has a strong will and commitment to conservation.

Table 2. National and international legislations concerning biodiversity in RSA.

National legislation	International conventions, treaties and protocols (ratification year)
• The Constitution (Act 108 of 1996) • White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity (1997) • White Paper on Environmental Management Policy for South Africa (1998) • National Environmental Management Act (Act 107 of 1998) (NEMA) • National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEM: PA) • National Environmental Management: Protected Areas Act (Act 57 of 2003) (NEM: PAA) • Marine Living Resources Act (Act 18 of 1998) • National Forest Act (Act 84 of 1998) • Provincial biodiversity legislation • National Biodiversity Strategy and Action Plan (2005) • National Biodiversity Framework (2008) • National Protected Area Expansion Strategy (2008)	• International Convention for the Regulation of Whaling 1946 (ICRW) • The Antarctic Treaty (1959) • International Plant Protection Convention (1952) • Convention on Wetlands (Ramsar Convention) (1971) • World Heritage Convention (1972) • Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1975) • Convention on Migratory Species (CMS) (1975) • UN Framework Convention on Climate Change (1997) • Convention on Biological Diversity (CBD) (1995) • The Convention to Combat Desertification (CCD) (1997) • The Cartegena Protocol on Biosafety (2003) • International Treaty on Plant Genetic Resources for Food and Agriculture (2004) • Nagoya protocol on ABS (2013) • Sustainable Development Goals (2015)

Source: DEA 2015.

2.3.4.2 Institutional context

Reflecting legislative commitment, there are a number of different institutions responsible for implementation of the aforementioned policies and laws. These include a range of national, provincial and municipal governmental departments and agencies, SANBI, numerous NGOs and intergovernmental structures (DEA 2005). The Department of Environmental Affairs (DEA), which was The Department of Environmental Affairs and Tourism (DEAT) until 2009, delegates provincial and municipal responsibilities concerning the environment, and its responsible for implementation and fulfilment of international obligations. DEA is also responsible for PAs in state possession, although the management of national parks has been transferred to a parastatal organisation, South African National Parks (SANParks). All abovementioned institutions play an important role in conservation, management of biodiversity and natural resources, but crucial institutions in light of this research are South African National Parks (SANParks) and the provincial government Limpopo Department for Economic Development, Environment and Tourism (LEDET), so their role will be described in more detail.

SANParks is a statutory authority mandated to 'conserve, protect, control and manage the system of national parks', which currently counts 20 national parks in RSA (DEA 2015.) SANParks also aims to promote South African 'natural and cultural heritage' at a local, national and international level and does this particularly through eco-tourism within the network of national parks, which generates a large proportion of its revenue (Child 2012). This self-generation capacity is necessary to supplement the funding received directly from government to manage conservation efforts. Although primarily in charge of the management, SANParks has extensive research and monitoring programme and its policy encourages collaboration with researchers from both local and international background (SANParks 2013). It is also involved in many poverty alleviation projects. Through the People and Conservation Department it has been working closely with the surrounding communities by establishing programmes for community outreach and skills and leadership development as well as sales outlets structures for community crafters to sell their products (SANParks 2017b). SANParks is recognised as contribute heavily to meeting national conservation objectives regarding South African biomes such as the Nama Karoo, Succulent Karoo, savannah, desert and wetland. A key element of SANParks work has been their ability to dramatically increase the size of protected area under the national park system since the evolution of the South African governmental system in 1994 (Castley 2012).

LEDET was established in 2004 and operates its headquarters in the provisional capital, Polokwane. The main strand of the organisation that has a conservation focus is the Environment and Tourism section, which can be further broken down into three areas, Environmental Trade and Protection, Biodiversity and Natural Resource Management; and Tourism and Community Environment Development (LEDET 2016). The department's main functions that are of importance to protected area and biodiversity conservation include making Limpopo a major eco-tourism destination, creating jobs through a sustainable environment and its management. This is achieved directly through the services offered by the Environment and Tourism section:

- *Issuing of environmental authorisations to applicants/developers.*
- *Issuing of wildlife permits for e.g. hunting.*
- *Community Environmental education through the Green Municipality Programme and the Schools State of Environment competition.*
- *Planning, promotion and management of tourism activities in the province.*
- *Manage air quality and waste management.* (LEDET 2016)

2.3.4.3 Protected Areas of RSA

Although not exclusive to RSA, the establishment of many PAs has been associated with colonial oppression and displacement of indigenous and rural communities from their own land, with very often exclusionary policies put in place (Brockington and Igoe 2006). Indeed, pre-1994 apartheid government policies in RSA led to forced removals of more than 3.5 million people, many of which were displaced from land rich in natural resources they were dependent on and conservation was coloured by racial injustice (Fabricius and De Wet 2002; Child 2012). Such land was converted into national parks and provincial nature reserves, and the people's relocation was justified as "*essential for the establishment of a representative and ecologically viable network of PAs*" (Fabricius and De Wet 2002). However, after the democratic elections in 1994, a process of land restitution was initiated through the Restitution of Land Rights Act No. 22. A Land Claims Court was established and many NGOs embarked on helping communities reclaim the land they had been displaced from after 1913 (Fabricius and De Wet 2002). This has positively impacted conservation in numerous aspects. It has improved the relations between PA management authorities and local stakeholders, increased the support for conservation and surprisingly, enabled expansion of conservation areas (Fabricius and De Wet 2002; Child 2012). Importantly, land restitution has provided a basis for innovation in conservation, with management models like *contractual parks* being developed. Essentially, contractual parks are established through a joint management agreement which lays out the rights and responsibilities of both sides: the landowner and management authority. This approach has been recognised as a potential solution for community-based threats and management issues, while at the same time an opportunity for further expansion of PAs on land that cannot be bought or included (Scheepers *et al.* 2011; Child 2012). For communities, contractual parks are a way of regaining land ownership rights, while profiting from tourism and resource use benefits (Scheepers *et al.* 2011; Child 2012). The first, and the most well-known contractual park in RSA is the Makuleke region of KNP, which was established after an agreement was reached between the Makuleke people and SANParks in 1998. The agreement has been widely recognised as one of the fairest models for co-management: Makuleke people agreed to use the land in accordance with conservation objectives, retaining rights for commercial development, while SANParks kept the revenue from gate entrance fees (Child 2012).

Another important aspect of PAs in RSA is the recently legally recognised concept of *buffer zones* around PAs. Globally, the concept was the result of realisation that PAs cannot be managed as static, isolated islands and that only when the relationship with the surrounding area is considered, the long-term conservation success in PAs will be accomplished (Bengtsson *et al.* 2003). It gained momentum as a conservation tool in 1970s through the UNESCO's Biosphere Man and Biosphere Programme (UNESCO 1974), which introduced the zoning hierarchy of buffer areas: the first layer of protection, around the core area (PA) is the *buffer zone* which is surrounded with *transition area*, where a greater level of land use is allowed. The principal idea is to isolate areas that have biodiversity conservation as their primary objective (core areas) from harmful external impacts, while allowing a certain level of sustainable human activities that are consistent with the protection of the core area. This is particularly relevant for RSA's PAs, many of which are located in highly-populated and extremely poor parts of the country. The Strategy on Buffer Zones for National Parks, adopted in 2012 outlines a clear mission of the strategy which is "*to best protect the integrity of national parks, their purpose and values while enabling sustainable benefits to those persons and communities living next to the national parks"*. Therefore, the strategy presents an invaluable contribution to the protection of PAs, but also a tool for increased inclusion of the local community.

There are a number of different forms of buffer zones, all with somewhat different objectives, including so-called ‘buffer parks’ around KNP.

Protected Areas Act (Act 57 of 2003) recognises several PA categories:

1. *special nature reserves, nature reserves, national parks protected environments* under the Act and provincial legislation;
2. *world heritage sites*, declared under the World Heritage Convention Act 1999;
3. *marine protected areas*, declared under the Marine Living Resources Act;
4. *specially protected forest areas, forest nature reserves and forest wilderness areas,* under the National Forests Act 1998;
5. *mountain catchment areas,* under the Mountain Catchment Areas Act 1970 (Paterson [2009?])

Definitions and categories clearly do not match entirely the IUCN Protected Areas Management Categories (Dudley 2008). Still, there are overlaps: special nature reserves are analogue to IUCN category Ia; national parks equal category II, nature reserves are somewhat similar to categories III, IV and V, while the protected environments roughly match categories V and VI. In addition to formally proclaimed PAs, there is a number of privately owned and managed reserves in the form of game reserves, game ranches and private conservancies (Paterson [2009?]).

Today, according to the World Database of Protected Areas (WDPA) there are 1,521 PAs in RSA, covering 14.11% of the terrestrial and 12.08% of marine area (UNEP-WCMC 2017). The National Register of Protected Areas provided a similar number in 2012, with 518 state owned and 1045 privately owned PAs.

2.3.4.4 PAME in RSA

PAME evaluation in RSA came into focus after the 5th IUCN World Parks Congress held in 2003 in Durban, during which the concept of PAME was chosen as one of the main themes (Anthony

2014). The outcomes of the congress have influenced the creation of a CBD Programme of Work on Protected Areas (PoWPA) which has obligated its signatories, including RSA, to implement and undertake PAME assessments in at least 30% of their national PAs (Dudley *et al.* 2005). As a response, a nation-wide assessment of RSA's national parks, nature reserves and forest reserves was conducted primarily using the METT tool, with two country-specific versions of the tool made over the years (Cowan *et al.* 2010). According to the report submitted to the CBD PoWPA, 171 PAs were assessed from 2004 to 2010, constituting 58% of terrestrial and 100% of RSA's marine protected areas (DEA 2012). In addition to the METT, many other individual evaluations have been undertaken across RSA utilising other tools (Anthony 2014), including MTRA in 4 administrative areas along the KNP border (Anthony 2008).

2.3.5 Kruger National Park (KNP)

Kruger National Park (KNP) is one of the largest national parks in the world, covering an area of approx. 20,000 km^2 in the north-eastern part of RSA. From north to south, it is approximately 350km in length and on average 60km in width, stretching across Limpopo and Mpumalanga provinces. It borders Mozambique along its entire eastern boundary, and numerous provincial and private nature reserves, as well as highly populated communities, to the west. In the north and south, it is naturally bound by Limpopo and Crocodile rivers.

KNP was declared as RSA's first formal national park in 1926 by merging two already existing provincial parks – Sabi Game Reserve, proclaimed in 1898, and Singwitsi Game Reserve, proclaimed in 1903 (Carruthers 1995). Both reserves were established to provide a sanctuary for southern Africa's wildlife that was devastated by decades of extensive hunting (dictated by the 19^{th}-century market and sports), rinderpest epidemic of 1986 and Anglo-Boer War of 1899-1902 (Carruthers 2013). Proclamation of a national park at that time provided a common conservation project that would unify English- and Afrikaans- speaking white South Africans (Carruthers 1995). The national sentiment and people's support was further deepened by the very name of the park, given after Paul Kruger, president of the Transvaal Republic prior to the war and an African hero (Carruthers 1995). The park's boundaries started being fenced as the agricultural development around the park increased and the controlling of animal movement became necessary. Fencing started with the southern boundary in 1959 and lasted until the 1980 when the fence around the entire park was completed (Carruthers 1995). As a national park, declared through the Act of Parliament of the Union of South Africa, it enjoyed legal security from de-proclamation and was supported financially from the government. Furthermore, it was now open for tourism development and subsequently, a management authority was created (Carruthers 2013). However, it is important to note that the unification of two white communities has also led to exclusion of black people from being involved in any activities in KNP for more than a century (Carruthers 1995). This created the still ongoing issue of lack of legitimacy among the three million black living people living adjacent to the park which is making park management challenging (Mabunda 2004). Today, KNP is part of the Great Limpopo Transfrontier Park (GLTP) and the wider Great Limpopo Transfrontier Conservation Area (GLTCA), which stretches across RSA, Mozambique and Zimbabwe. It also forms a part of the Kruger-to-Canyons (K2C) UNESCO Biosphere Reserve (SANParks 2008).

KNP represents one of the most visited tourist attractions in RSA with 1 767 218 visitors in 2015 (SANParks 2016). There are 21 rest camps, two private lodge concessions, 15 private safari lodges and several bushveld camp sites reachable by a network of tar and gravel roads. KNP has nine entrance gates, which makes it highly accessible to visitors that can enjoy different activities such as self-drive safaris, four by four eco-trails, morning and evening game drives, day walks, bush braais and other (SANParks 2008).

KNP's biodiversity is enormous; due to its size, it has very diverse climatic conditions which form numerous vegetation types and support various habitats. According to Gertenbach (1983), there are 35 distinctive landscapes within KNP, which he defines as "*an area with a specific geomorphology, macroclimate, soil, vegetation pattern and associated fauna*". He based the classification on the numerous studies done about each of these elements in an attempt to divide KNP in units for practical management. These can be divided further into 16 ecozones (Jacana Education 2000). At a very coarse level, vegetation can be divided into three major zones: (i) the southwest zone, with soil lower in nutrients and more abundant in rain, is well-wooded area with trees like bushwillows (*Combretum* species, especially *C. apiculatum*), knobthorn (*Acacia nigrescens*), tamboti (*Spirostachys africana*) and marula (*Sclerocarya birrea*); (ii) the southeast zone, with productive grasslands and some trees such as knobthorn, marula and leadwood (*Combretum imberbe*). And (iii) the northern zone, which is open and dominated by mopane (*Colophospermum mopane*) and can be split into the eastern, more fertile half with open grasslands and north-western woodlands with bushwillow trees (SANParks 2008). In terms of species richness, there are 2000 plant species in the park, including 400 trees and shrubs and 200 grass species. KNP has an immensely diverse fauna, with 53 fish, 35 amphibian, 118 reptile and 505 bird species (SANParks 2008). Among 148 species of mammals, many are large predator and ungulate species that attract visitors that come to the park for safaris (SANParks 2008). Most tourists come to see the big five: elephant (*Loxodonta Africana)*, black rhinoceros (*Diceros bicornis*), leopard (*Panthera pardus*), lion (*Panthera leo*) and the African buffalo (*Syncerus caffer*). KNP also provides habitat for critically endangered species, with the black rhino, wild dog

(*Lycaon pictus*), pepperbark tree (*Warburgia salutaris*), wild ginger (*Siphonochilus aethiopicus*) and Swazi impala lily (*Adenium swazicum)* being the main ones. In addition to native species, there is roughly 375 invasive alien species (IAS) in the park, most of which are plant species (SANParks 2008).

As previously mentioned, all national parks in RSA, including KNP, are managed by SANParks. The management practices have changed since the establishment of the park and evolved from an optimisation approach used until the 1980s, command and control and laissez-faire methods of management used until 1995, into a system of strategic adaptive management (SAM) that is in place today (Roux and Foxcroft 2011). SAM came into being as the awareness about the importance of local stakeholders and the complexity of the relationship they have with the PA was increasing (Scheepers *et al.* 2011), meaning it includes both the adaptive and participatory approaches discussed in section 2.1.2. Therefore, the management plan of the park has been produced jointly with stakeholders, who have been engaged in the management planning through general consultations, focus group meetings and capacity development sessions (SANParks 2008). The last approved version of the plan was made in 2008, but a draft of the new, updated plan is currently being reviewed. In summary, the plan contains a clearly formulated mission, vital attributes of the park, sets of strategic objectives, zonation plan and thresholds of potential concern (TPCs), which together compose the desired state of the KNP (SANParks 2008). The park's mission and highest level objectives are shown in Figure 2.

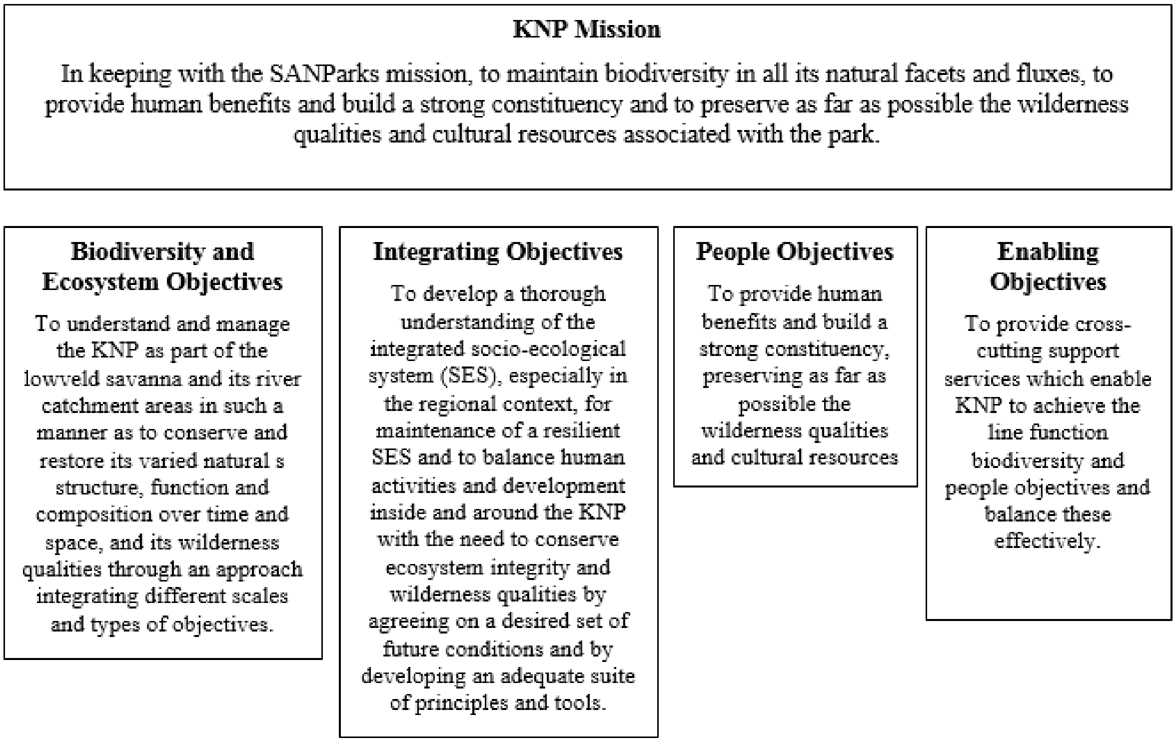

Figure 2. KNP Mission and objectives. Source: SANParks 2008.

According to NEM:PAA, every management plan is required to have a zonation plan which indicates which activities are allowed in which zones of the park. With slight changes in spatial distribution and extent and of the zones demarcated in 2011, the zonation plan includes the following management zones in the park:

1. *Wilderness Zone* (45% of the park) – areas with minimal management interventions, that "*retain an intrinsically wild appearance and character"* (SANParks 2008). There are no roads in this zone, only management tracks necessary for anti-poaching ranger patrols.
2. *Remote Zone* (12%) – areas that still give a wilderness experience, but are not defined by law as wilderness. Some evidence of human presence from outside the zone might be seen or heard. There are only small anti-poaching management tracks.
3. *Primitive Zone* (30%) – areas with wilderness characteristics and restricted access for visitors. There are a limited number of roads and bush camp accommodation amenities.

4. *Low Intensity Leisure Zone* (8%) – areas with marginally modified landscapes and developed roads for bigger groups of visitors. Small camps and picnic sites are also present.
5. *High Intensity Leisure Zone* (5%) – areas with highly-concentrated tourism development. Infrastructure and road network is well developed.

For management purposes, KNP is divided into four regions that are further divided in ranger 22 sections. There is a clear hierarchy in the management system: each region has a regional ranger, responsible for supervision of the section rangers, who are responsible for field rangers of their section. In addition, there is the SANParks Honorary Rangers Corps, a voluntary movement that assists in a range of tasks associated with the SANParks agenda and directly with park management activities (SANParks 2008).

This research will focus on Mahlangeni and Phalaborwa sections which border LRNR (Figure 3). Mahlangeni covers an area of approx.1160km^2 of mopane-dominated woodlands on granite (Gertenbach 1983). Phalaborwa section is slightly smaller, covering 1035km^2 of mopane-dominate woodlands, with some mixed woodlands on granite (Gertenbach 1983). One of the park's gates, the Phalaborwa gate, is located in this section.

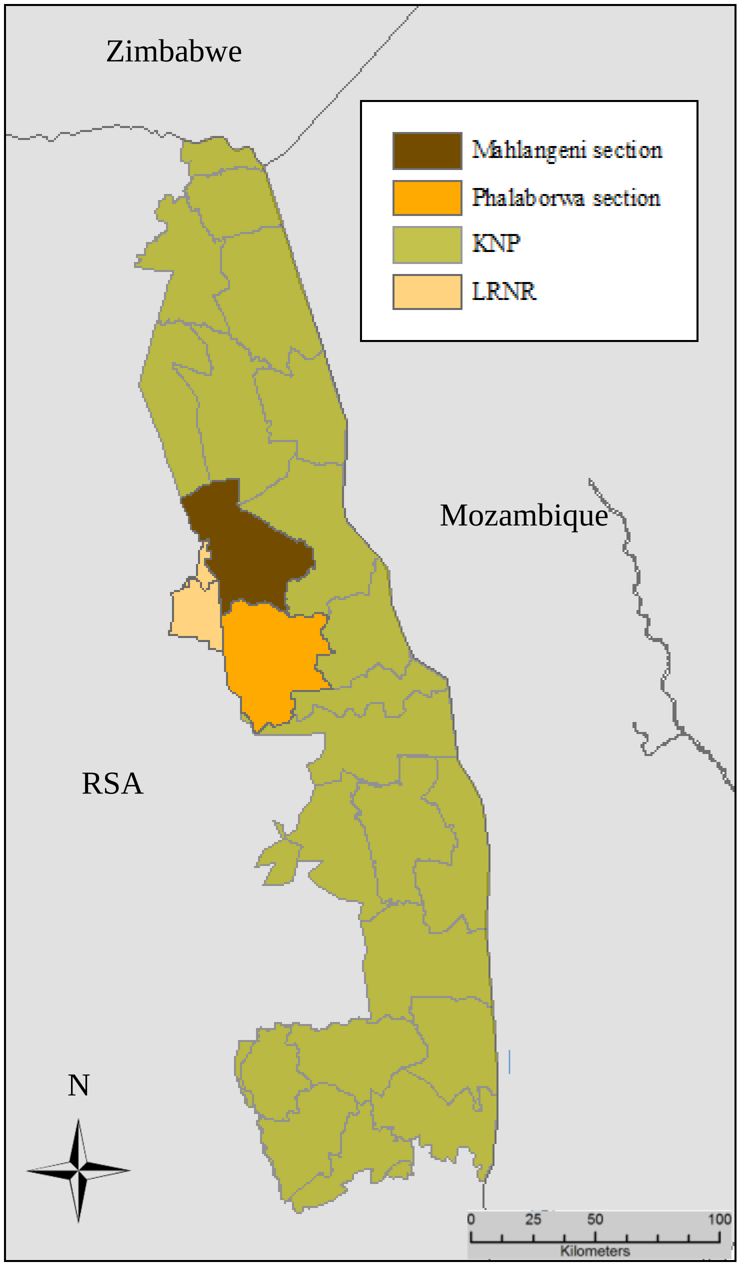

Figure 3. Kruger National Park with the adjacent Letaba Ranch Nature Reserve.
Source: Adapted from SANParks 2008, LEDET 2013.

2.3.6 Letaba Ranch Nature Reserve (LRNR)

The LRNR is located in Ba-Phalaborwa and Greater Giyani Municipalities of the Mopani district in Limpopo Province in South Africa, covering a total area of 420 km^2. It is positioned along the western boundary of KNP (Figure 4), northern from the Phalaborwa Gate, serving as a buffer zone of the park. Mthimkhulu Nature Reserve (MNR), covering 63.49 km^2 north of the Groot Letaba River, is incorporated into the LRNR (LEDET 2013).

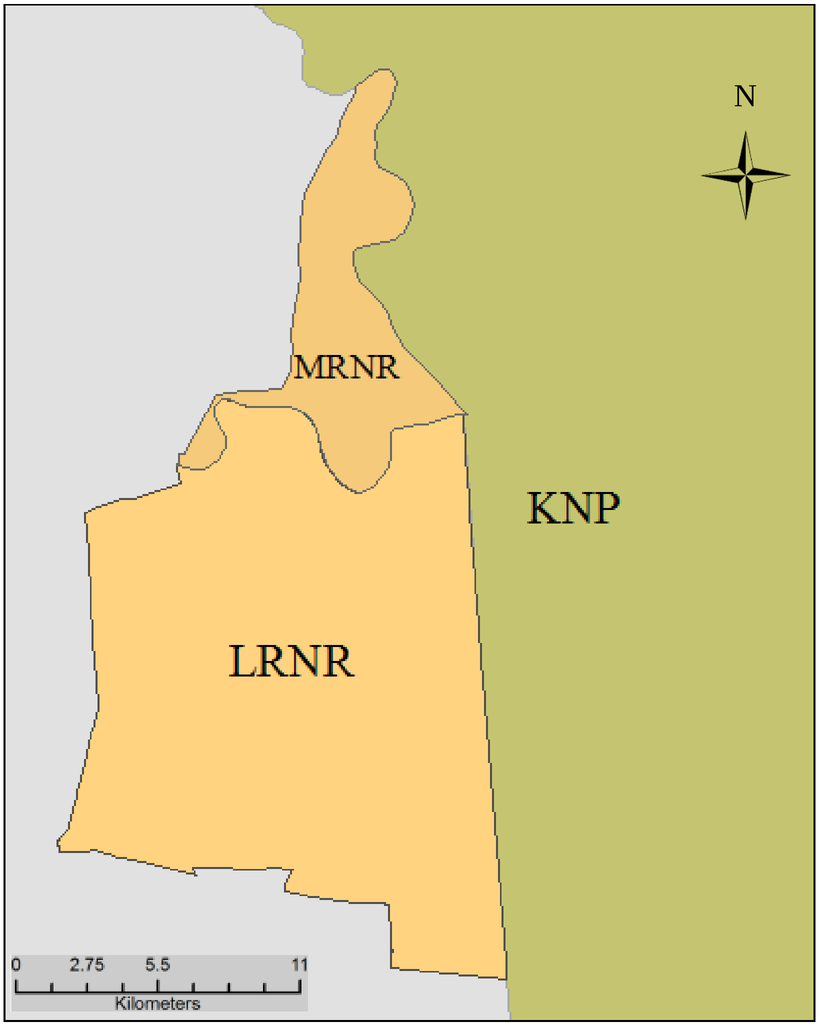

Figure 4. Location of the Letaba Ranch Nature Reserve next to Kruger National Park.
Source: Adapted from SANParks 2008, LEDET 2013

The LRNR was established in 1965 as a game and native flora reserve named the Rondalia-Letaba Private Nature Reserve. At the time, it was used as a game reserve by the Department of Agriculture and for training sessions by South African Nature Foundation (SANF). The area was then de-proclaimed as a reserve in 1975 and transferred to the Gazankulu homeland, after which it was used solely as a game reserve (LEDET 2013). Today, the National Environmental Management: Protected Areas Act, 2003 (Act No.57 of 2003) (NEM:PAA) does not legally identify LRNR as a provincial nature reserve, and as such, lacks legal protection of NEM:PAA. Nevertheless, various national, regional and provincial legislation, including NEM:PAA is applied on management activities of the reserve. Table 3 lists the key ones. Both the Ba-Phalaborwa Local Municipality Integrated Development Plan (IDP) (BPM 2016) and Mopani District IDP (MDM 2016) recognise the LRNR as a valuable conservation area.

Table 3. Legislations applied on managament activities of Letaba Ranch Nature Reserve.

National legislation	Provincial and Local Legislation
• National Environmental Management Act (Act 107 of 1998) (NEMA) • National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEM: BA) • National Environmental Management: Protected Areas Act (Act 57 of 2003) (NEM: PAA) • National Environmental Management: Waste Act, 2008 (Act 58 of 2008) (NEMWA) • National Forest Act, 1998 (Act 84 of 1998) • Agriculture Laws Extension Act. 1996 (Act 87 of 1996) • Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983) (CARA) • Environment Conservation Act, 1989 (Act 73 of 1989) • National Water Act, 1998 (Act 36 of 1998) • National Veld and Forest Fire Act, 1998 (Act 101 of 1998) (NVFFA) • National Heritage Resources Act, 1999 (Act 25 of 1999) (NHRA) • Animal Diseases Act, 1983 (Act 25 of 1999) • Animal Health Act, 2002 (Act 7 of 2002) • Game Theft Act, 1991 (Act 105 of 1991)	• Limpopo Environmental Management Act, 2003 (Act 7 of 2003) • Limpopo Tourism Act, 2009 (Act 2 of 2009) • Ba-Phalaborwa Local Municipality By-Laws, 2009 (Local Authority Notice 277)

Source: LEDET 2013.

The conservation value of the reserve lies within its location, diverse vegetation units and rich biodiversity. Besides its value as a buffer zone, LRNR is part of the Letaba River system with two major rivers flowing through the reserve: Groot Letaba and Klein Letaba rivers which join along the eastern boundary of the reserve and form the Letaba River which flows through KNP (LEDET 2013). LRNR vegetation comprises Mopane and Lowveld Bushveld units of a savanna biome, spatially divided into 4 zones based on the geology and plant forms found: Granite Lowveld, consisting of tall shrubland and low dense woodland, Lowveld Rugged Mopaneveld, made of dense shrubland with few trees, Phalaborwa Timbavati, open tree savanna and Tsende Mopaneveld, medium shrub savanna with scattered trees (Mucina and Rutherford 2006). Mucina and Rutherford (2006) describe Granite Lowveld as vulnerable and moderately protected, which further illustrates the importance of the reserve. In addition, two plant species of conservation concern occur within the reserve (POSA 2017). When it comes to the reserve's fauna richness, LRNR's heterogeneous landscape and diverse habitat types support a high number of species. It is home to more than 36 mammal species, including leopards, lions, white rhinos (*Ceratotherium simum*), cheetah (*Acinonyx jubatus*) and wild dogs, all of which are of conservation concern (LEDET 2013). As the fence between KNP and LRNR was removed in 2005, the reserve also serves as an overflow for game from KNP (LEDET 2013). LRNR is particularly rich in avian fauna, supporting 101 bird species, seven of which are considered near-endemic (LEDET 2013). Five bird species are listed as vulnerable on the IUCN Red List of Threatened Species, with Martial (*Polemaetus bellicosus*) and Tawny Eagle (*Aquila rapax*) breeding pairs being of specific importance as they are apex predators of the given ecosystem. There are also 31 amphibian, 31 fish and a number of reptile species. Species richness of the reserve is potentially considerably higher and the complete species inventory is yet to be determined (LEDET 2013).

LRNR represents the largest provincial nature reserve managed by LEDET, with a total of 36 staff members: 1 reserve manager, 1 senior field ranger, 32 field rangers and 2 general assistants. Co-management agreements with Mthimkhulu and Majeje Tribal authorities are currently being drafted and are to be applied in portions of the land within the reserve owned by these communities (LEDET 2013). According to the Letaba Strategic Plan, cooperation between LEDET and Majeje community in the southern part of the reserve is more successful than the relationship with Mthimkhulu community in the north, which represents an obstacle in management of the reserve and will be discussed in the later chapters. In addition to LEDET, Limpopo Tourism Agency (LTA) is responsible for tourism management of the reserve (LEDET 2013).

2.3.7 Conclusion

Considering the global recognition of the importance of PAME evaluations, increasing pressures to RSA's biodiversity and its strong commitment to conservation, a need for increased monitoring management effectiveness was recognised. The gap is particularly apparent in light of the recently legally adopted concept of buffer areas in RSA, which have the objective of supporting the ecological integrity core areas they are surrounding. MTRA will reveal the changes in threats to biodiversity in one of those buffer areas, LRNR, and in the KNP sections it borders, Mahlangeni and Phalaborwa. Combined with geospatial element, records review and interviews, the results will help determine if the buffer park is meeting its objective, or further exposing the park to threats. Results will also allow comparison across sites and identification of successful management interventions.

3. Methodology

3.1 Introduction

This chapter provides a detailed explanation of *how* the research was carried out, *why* the applied methods were selected and *what* steps were taken. Overall, the research mainly consists of three parts: 1) preparatory activities, including data collection through literature review, preliminary correspondence with stakeholders in the area and preparation of base maps, 2) the execution of the MTRA tool and GIS data collection, and 3) data analysis and production of threat maps.

3.2 Research design

This research combined qualitative and quantitative methods. Qualitative methods included a records review, to provide better understanding of the problem, and informal interviews with stakeholders from the area to get insight into local conditions. Quantitative methods consisted of MTRA workshops at three selected sites and spatial analysis using Geographic Information Systems (GIS).

3.3 Qualitative methods

3.3.1 Records review

Aiming to better understand the research problem and the local background, a comprehensive review of records was done. Review of the literature about main foundational concepts such as biodiversity, conservation and PAME mainly included books, scientific journals and specialised reports from organisations such as WWF and IUCN. In addition, official governmental reports and online sources were consulted in order to understand the local context and conditions. National reports, such as those submitted to the CBD Secretariat and the South African National Biodiversity Assessments were consulted to obtain information about the state of the biodiversity in RSA and the level of current protection. Similarly, national legislation tackling conservation was thoroughly reviewed, in addition to local municipal and provincial development plans, KNP Management Plan and LRNR Strategic Plan. Lastly, previous TRA and MTRA studies were consulted to fully understand the administration of the tool (Anthony 2008; Matar 2009; Ganbaatar 2011; Anderson 2012; Kovalenko 2012; Loughney 2013). All the information gathered was then combined and summarised into a literature review provided in Chapter 2.

3.3.2 Informal interviews

To understand the management and governance of LRNR, especially its northern part, several informal interviews were conducted. The interviews included two locals from the Phalubeni village neighbouring MNR, the chief of the Mthimkhulu community and the community-assigned reserve manager.

3.4 Quantitative methods

3.4.1 MTRA

Threat Reduction Assessment (TRA), as previously mentioned, is based on the idea that the conservation success can be indirectly measured through the monitoring of direct threats to the biodiversity within the PA (Margoluis and Salafsky 2001, Tucker 2005). The TRA approach assumes the following:

1. "*All destruction of biodiversity is human-induced;*
2. *All threats to biodiversity at the given site can be identified and ranked according to the area, intensity and urgency at any point in time;*
3. *Changes in all threats can be measured or estimated"* (Margoluis and Salafsky 2001).

The modified version of the tool, MTRA, was selected as it has an added advantage of incorporating worsening and emerging threats into the assessment, thus increasing the accuracy and representativeness of the results (Anthony 2008).

3.4.1.1 Justification

As the aim of this research is to evaluate management effectiveness in the selected PAs, it was important to select a suitable PAME tool to do so. Considering the MTRA method advantages discussed in section 2.1.5., this tool was chosen over others and found suitable for this study for the following reasons:

- It allows for comparison between sites
- It does not require previously collected baseline data
- It is relatively easy to apply and does not require major preparations, which makes the management monitoring possible even without highly trained staff
- It is cost-effective

Previously conducted MTRAs have identified group discussions as the most effective way of applying the tool, with workshop style being found especially suitable (Anthony 2008; Matar 2009). The chosen method contributed to the tool with additional advantages:

- It is not time-consuming, as the workshops did not last longer than 3h,
- It allows everyone's opinion to be taken into account, as the workshop moderator can facilitate the discussion and prevent only the most dominant people to have an input
- The workshop setting allows for a more diversified group of participants, where rangers with different levels of experience and knowledge can contribute equally.

3.4.1.2 Preliminary preparations

The administration of a MTRA required active engagement and participation of management staff of the selected PAs. In order to facilitate the workshops, introductory emails and workshop materials were sent in advance. The emails included a brief introduction about the researcher and the purpose of the research, and a MTRA Workshop Package to help managers familiarise with the tool before the workshop. The package included a summarised explanation of the tool, detailed explanation of the steps to be taken during the workshop (Margoluis and Salafsky 2001), the most recent version of the standard lexicon of threats (Salafsky *et al.* 2008), and worksheets needed for threat definition and TRA Index calculation (Appendix B). Finally, it included blank site maps and the explanation of GIS method.

Due to the contacted park managers being in higher positions in the park management hierarchy (section rangers and the reserve manager, in KNP and LRNR, respectively), they were given the task of selecting participants in addition to themselves. Therefore, the email also contained the criteria for participant selection. It was emphasised that field rangers should fulfill the following in order to be found suitable for participating in the workshop:

1. Have experience in the area, meaning that they should have worked in the area during the entire assessment period to be able to evaluate the changes in threats;
2. Be knowledgeable of the site,
3. Be familiar with concepts such as biodiversity, habitat conditions and ecosystem services, as these concepts are important when conceptualising threats in the area.

Additionally, the ability to speak English language was given as a preference, although it was not required. After confirming the date and time for the workshop, each management team was asked to review the package documents and bring previous management effectiveness evaluations to minimise the subjectivity of the evaluation and increase the validity of the method.

3.4.1.3 Workshop administration

Three MTRA workshops were conducted: two in Mahlangeni and Phalaborwa sections of KNP, and one in LRNR. Each workshop started with a power point presentation introducing the methodology, key concepts and definitions, as well as step by step explanation of the workshop. In addition, participants were given handouts containing the same information and the standard lexicon of threats, to consult during the workshop. Steps were undertaken following Margoluis and Salafsky (2001), which identifies the following crucial TRA steps:

1. *Defining the area and the assessment period*; which was done by the workshop moderator. Spatially, the workshop assessed the area 5 km from the fence inside the Mahlangeni and Phalaborwa sections of KNP (Figure 5)., and the whole of LRNR

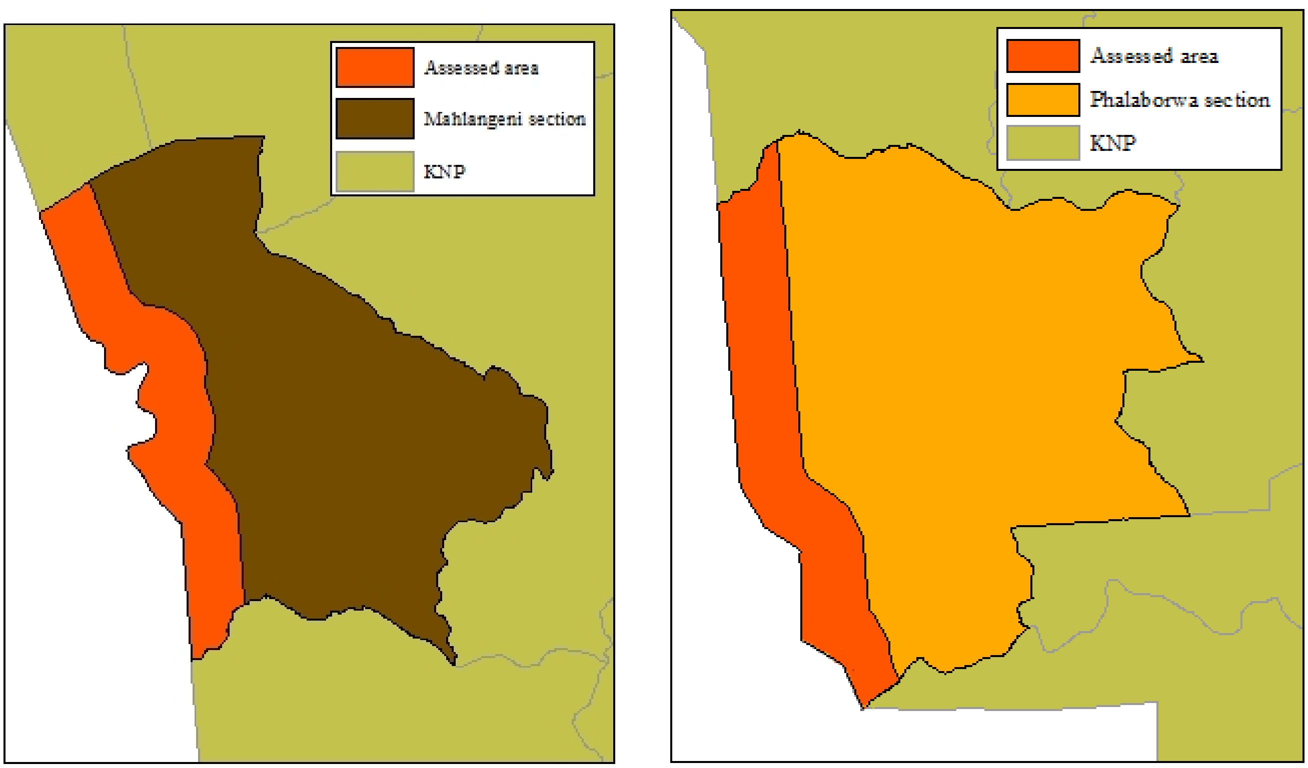

Figure 5. Assessed areas in KNP sections.

The area was decided based on the aim of the research, which is to identify and compare the threats along the border between these two PAs and attempt to identify their sources. LRNR was assessed as a whole, as various settlements bordering its northern, western and southern boundaries can be sources of threats that put pressure on the reserve's biodiversity which are then transferred further into KNP. Temporally, the assessment period was selected to be from 2013 until the present date, since that was the year LRNR adopted their five-year Strategic Plan. The same timeframe was used for KNP in order to allow for comparison.

2. *Developing a list of threats found in the PA*; participants were instructed to identify direct threats present at the beginning of the assessment period in their area and list them. After developing the final list, the top ten threats were chosen and categorised according to the IUCN lexicon, but only including 2 sub-categories (Salafsky *et al.* 2008). Rangers were also asked to describe the specifics of the identified threats in their area, to minimise the possible loss of information resulting from threat standardisation (Anthony 2008). In case participants had difficulty identifying threats, the lexicon was consulted during the discussion.

3. *Defining the threats and 100% reduction target;* participants were asked to agree on detailed definitions of the identified threats and determine what a 100% reduction of that threat would be. The moderator defined a 100% threat reduction 'as complete eradication of a given threat', following Anthony (2008), who notes that any other definition may cause ambiguity. However, if participants recognised that total elimination is not feasible, a different definition of 100% reduction was made.

4. *Ranking the threats according to their area, intensity and urgency;* participants were given time to discuss the ranking of each threat in regards to its area, intensity and urgency. The scoring scale was defined depending on the number of identified threats, with number 1 being the minimum score without the possibility of equal scoring. Participants were advised to look at the materials to minimise the subjectivity and increase the validity of the method.
5. *Adding up the ranking scores;* criteria scores were added up to make a 'total ranking' for each individual threat. Rangers were then asked to look at the rankings and decide if this is the true representation of the threats in their area. This allowed them to modify their rankings and increased the legitimacy of results.
6. *Determining the degree to which each threat has been reduced;* participants were then given time to independently think about how much the threat has increased or decreased over the assessment period and estimate a percentage reflecting that change. After a group discussion, they decided on the final percentage for each threat (Anthony 2008). If the threat has been mitigated, they gave a positive score, with the top score being +100% if the threat had been completely eliminated. If a threat has worsened since the start date, the given score was negative. However, there was no top negative score, so if something had worsened by an order of 4 times, that threat can be given a score of -400%. If a threat was not present at the assessment start date, but has emerged since then, that threat was given a score of -100%.
7. *Calculating raw scores;* calculated for each threat by multiplying the total ranking by the estimated percentage of change (Margoluis and Salafsky 2011).

8. *Calculating TRA Index;* according to the formula defined by Margoluis and Salafsky (2011):

$$\textbf{TRA index} = \sum \textbf{raw scores/ total rankings*100}$$

Due to the high number of participants (8, 12 and 8 in Mahlangeni, Phalaborwa and LRNR, respectively), all information was collected by the moderator and projected on the wall during the workshop. At the end of each workshop, there was an informal discussion about the management interventions at the given PA and how successful or unsuccessful they were in mitigating the identified threats.

3.4.2 Geospatial mapping of the threats

Geographic Information Systems (GIS) was chosen as method to visualise the changes in biodiversity threats identified during the MTRA workshops. The method relies on geospatial data to "*prepare, present and interpret facts*" (Tomlin 1990). The importance of GIS for environmental management has been recognised widely (Terfay and Schrimpf 2002) since it facilitates better resource allocation and more focused management actions. Moreover, produced maps can assist management teams synthesise and disseminate information to stakeholders, both inside and outside the PA. This is especially important in PAs with scarce resources and limited investment in spatial analysis methods.

3.4.2.1 Instruments

For this particular research, two different software were used. First, for the preparation of site maps, open-source GIS application called QGIS® or Quantum GIS was utilised. This programme has all the necessary tools and was available for download for free, which made map preparations possible during fieldwork in RSA. Digital data sets needed for the production of blank base site maps included:

- Shapefile data set on KNP boundaries (acquired from SANParks)
- Shapefile data set on Mahlangeni and Phalaborwa sections of KNP (acquired from SANParks)
- Data set on the boundaries of LRNR, including MNR (developed by SAEON technician as a KML file and then converted by the author to a shapefile using QGIS)

There were a number of tools used for producing the maps, most notably the MMQGIS plugin to create the 5 km buffer zone in the KNP sections. For data analysis, the author used ArcGIS®.

3.4.2.2 Geospatial data collection

Geospatial data collection was carried out following Anderson (2012) who mapped the threats previously in a PA in Ghana. The process included a brief explanation of the geospatial threat visualisation method and its purpose to the workshop participants at the end of each MTRA workshop. They were then given two blank site maps and instructed to collectively draw the approximated location of threats identified during the MTRA. After discussing each threat and deciding on its approximate location, threats at the beginning (2013) and end (2017) of the assessment period were drawn on separate maps to avoid overlapping and confusion during the data analysis. In addition, as the change in area of the threat does not necessarily mean that the threat has been mitigated/worsened, participants were asked to also rank the threats according to intensity and urgency on a scale from 1-3 (1 = low, 2 = moderate, 3 = high). To orientate themselves better and substantiate the method, participants consulted their daily patrol maps.

3.4.3 Data analysis

Maps produced during the MTRA workshops were digitised and analysed in ArcGIS 10.2. Each threat was made as a separate layer and then merged to produce final maps. In total, six maps displaying the changes in threats to biodiversity were produced: two per section of KNP and two for LRNR, with one representing the beginning of the assessment period and one showing the present state in each of the sites. As for the MTRA results, identified threats were compared across the sites and analysed using the information gathered through records review and informal interviews.

3.4.4 Study Limitations

There are several limiting factors for this research that should be mentioned. Firstly, time constraint was the main limitation for completing the study in the way it was previously imagined. Given the timeframe of only four weeks to conduct fieldwork, it was impossible to include all relevant stakeholders into the research. However, thorough records review, discussion with the rangers during the workshops and conducted interviews minimised the impact of time constraint on the results.

The second limitation is people's general reluctance to reply to emails and calls, which combined with the limited time, made the organising of workshops extremely difficult. As previously mentioned, KNP is a popular research centre and numerous research projects are undertaken every year, most of which require a level of ranger's contribution. This has potentially made the management staff less prone to participate in yet another research. However, this is applied only to the preparatory phase as the number of management staff that actually participated in the workshop was extraordinary. This is particularly true for the workshop in Phalaborwa, where 12 rangers participated in the research. Although the high number of participants definitely makes the discussion more difficult to manage, it is believed that the main reason for the workshop to be as demanding as it was it the absence of their superior, the section ranger.

As previously noted, there are some disadvantages in the MTRA method (section 2.2.4.), with subjectivity in measurements being the main one (Margoluis and Salafsky 2001; Anthony 2008).

This was also recognised by participants during the workshop, with many pointing out the possible bias in the results. However, the high number of participants, although at times making the workshop execution more difficult, increased the objectivity and the validity of the results. Potential bias further originates from the susceptibility to memory loss (Papworth *et al*. 2009). Sending information about workshops beforehand, encouraging the participants to bring supporting documentation about threats, and choosing a shorter assessment period (5 years), were all strategies employed to minimise this bias. Further, when conducting TRAs, there is a risk of management staff overstating the threat reduction percentage in order to present their PA management as successful (Margoluis and Salafsky 2001), especially if being compared to other PAs. Nonetheless, problem was not evident in either of the PAs, as workshop participants were willing to assign high negative scores to certain threats, without thinking about the final TRA index and were not informed about the intention to conduct workshops in other PAs.

Lastly, inaccessibility of the needed materials for data analysis, such as protocols, operational plans and management reports, limited the depth in which the results can be understood. This is partially due to the reports holding sensitive data about some of the threats e.g. poaching that management authorities are not willing to share. Nevertheless, records review and geospatial data facilitated the sufficient level of analysis of the MTRA results needed for this research.

4. Results

4.1 Introduction

In this chapter, MTRA workshop and geospatial threat modelling results are presented and interpreted for each of the sites assessed. First, a brief summary of MTRA workshop results from each site will be provided, together with the generated threat maps. Then, the threats are analysed and compared across all three sites, with a special focus on the source of the threat and management interventions in place that aim to mitigate them.

4.2 LRNR

4.2.1 Workshop results

The workshop was conducted at the LRNR main office and attended by eight participants in total (seven field rangers and the reserve manager). All of the rangers had been working in the reserve throughout the whole assessment period, with the majority being there for more than 20 years and some being brought in only in 2012. However, less experienced rangers have completed some level of education in biodiversity conservation (or similar) and were more familiar with the discussed concepts so they were able to complement each other. Since some of the participants did not speak fluent English, a translator was also present during the workshop.

Workshop results, including the TRA calculations and the list of identified threats are provided in Table 4 below. The reserve management team identified ten major threats to the reserve's biodiversity. The TRA index has a negative value of -33.6% showing that the total threats have worsened since the beginning of the assessment period. This is largely due to two newly emerged threats, 'mining' and 'droughts', that have been given a score of -100% accordingly. In addition, the issue of 'problematic native species' has doubled since 2013, further contributing to the negative index outcome. Despite the minimal reduction of 5%, ‘hunting’ was recognised as the top threat according to the total ranking, followed by ‘droughts’ and ‘fishing’, the latter remaining unchanged according to the management team. ‘Invasive alien species’ and ‘wood harvesting’ have both been halved, while the pollution from ‘agricultural effluents’ from surrounding crop land and ‘garbage and solid waste’ have worsened. Rangers also recognised ‘dams’ in the reserve as a threat, but identified no change during the assessment period.

Table 4. Threat Reduction Assessment Index for the Letaba Ranch Nature Reserve (LRNR)

No.	Threat	IUCN threat code	Ranking Criteria			Total Ranking	% Threat Change	Raw Score
			Area	Intensity	Urgency			
1.	Hunting and collection of terrestrial animals	5.1	10	10	7	27	+5%	1.35
2.	Drought	11.2	9	9	6	24	-100%	-24
3.	Fishing	5.4	6	8	9	23	0	0
4.	Invasive alien species	8.1	7	6	8	21	+50%	10.5
5.	Mining	3.2	2	7	10	19	-100%	-19
6.	Dams	7.2	5	5	3	13	0	0
7.	Agricultural effluents	9.3	4	4	5	13	-70%	-9.1
8.	Wood Harvesting	5.3	8	2	2	12	+50%	6
9.	Problematic native species	8.2	3	3	4	10	-200%	-20
10.	Garbage and Solid Waste	9.4	1	1	1	3	-40%	-1.2
		Total	55	55	55	165		-55.45
						TRA INDEX		-33.6

4.2.2 GIS Results

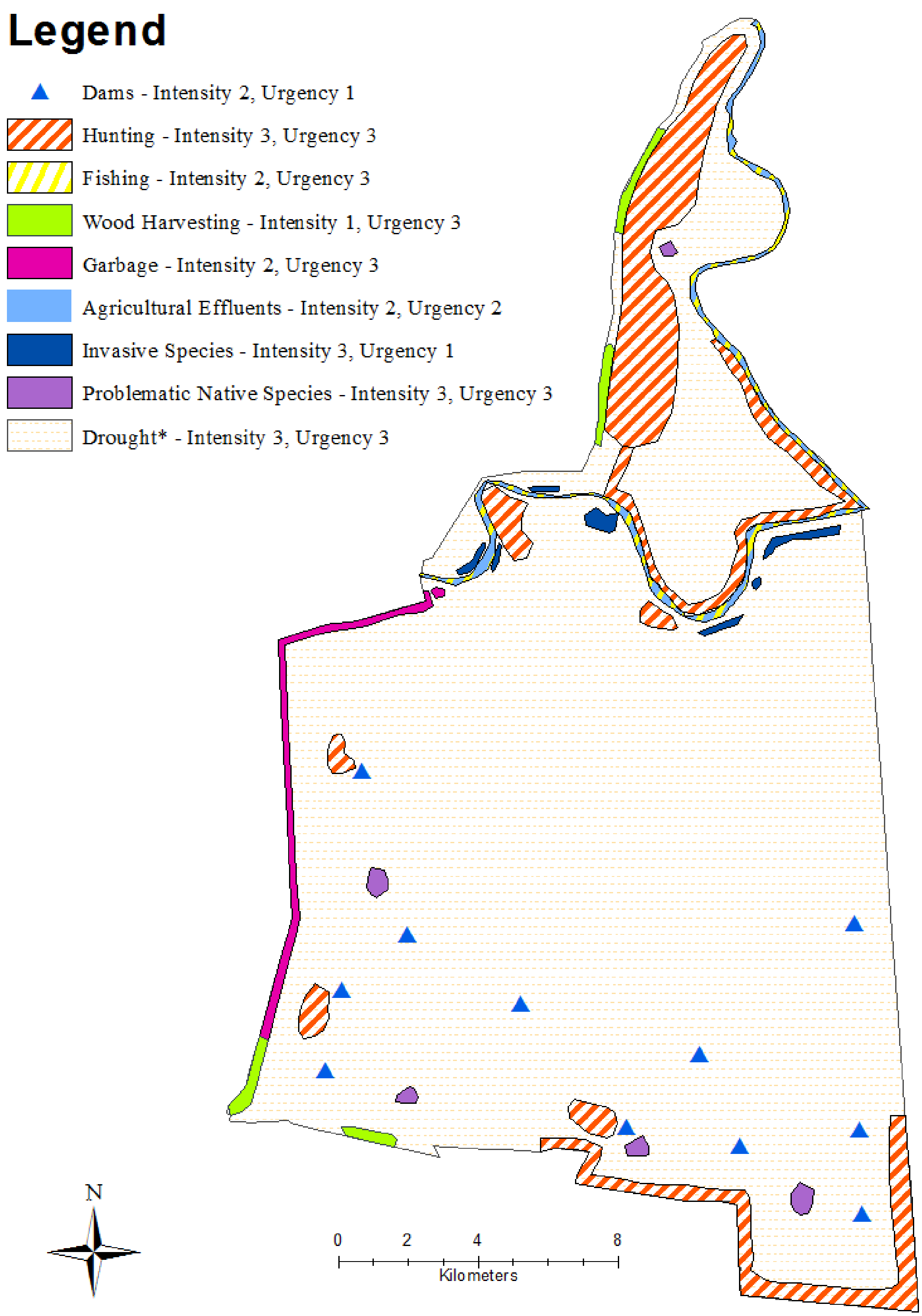

Figure 6. Threats to LRNR's biodiversity in 2013.
*drought was not present in 2013, but in 2014. However, the management team wanted to have it on a map to illustrate the scale of the problem by showing the area it affected.

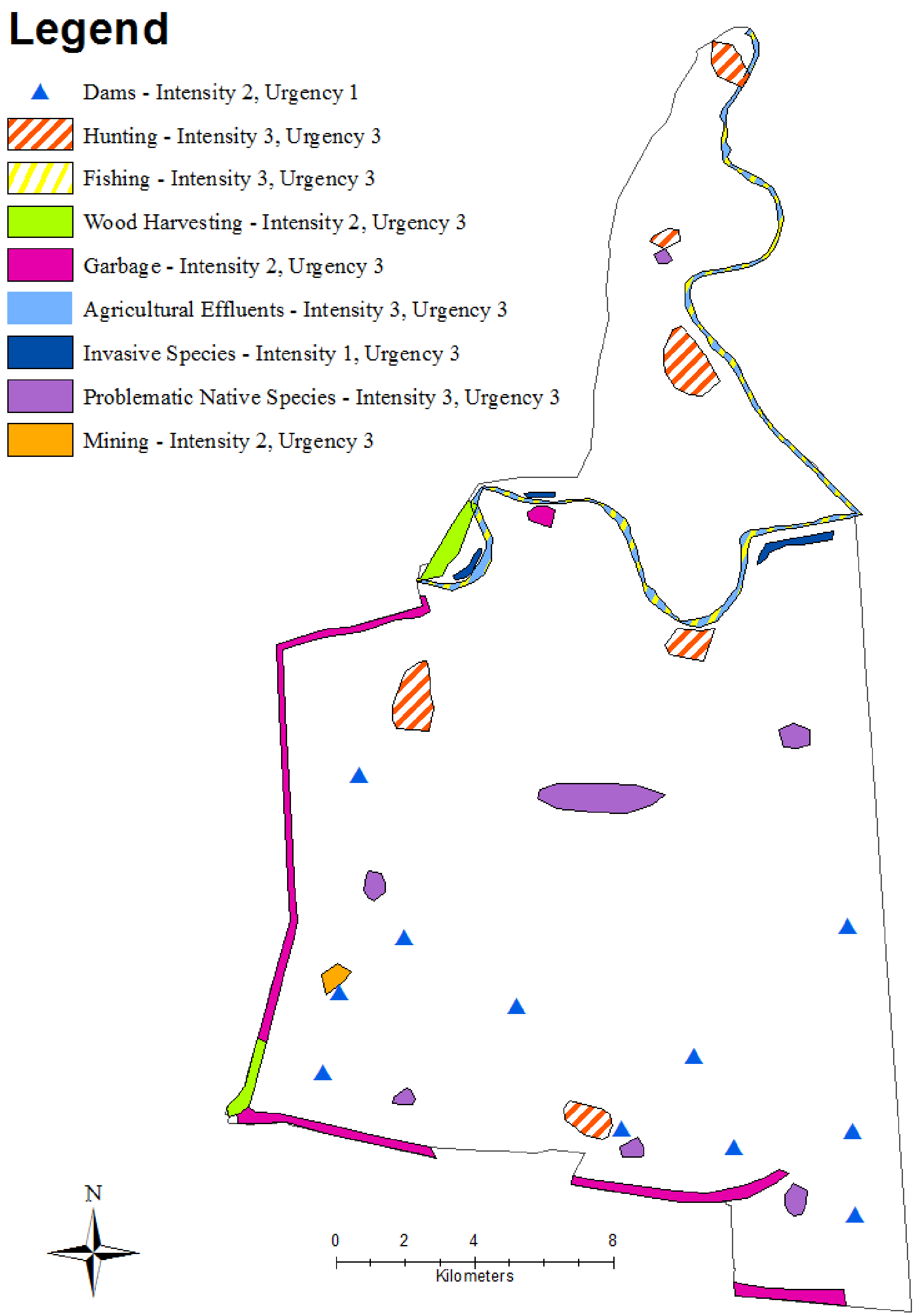

Figure 7. Threats to LRNR's biodiversity in 2017.

4.3 Mahlangeni section

4.3.1 MTRA workshop results

The workshop in Mahlangeni was conducted in the main section offices and was attended by eight rangers, including the section ranger. Again, it was ensured that all the participants have been working in the area since 2013. Workshop results with the list of identified threats and the TRA Index are presented in Table 5.

Table 5. Threat Reduction Assessment Index for Mahlangeni section of KNP

No.	Threat	IUCN threat code	Ranking Criteria			Total Ranking	% Threat Change	Raw Score
			Area	Intensity	Urgency			
1.	Hunting	5.1.	7	7	7	21	+49%	10.29
2.	Fishing	5.4.	6	6	5	17	-50%	-8.5
3.	Invasive Alien Species	8.1.	4	4	6	14	+70%	9.8
4.	Fire and Fire Suppression	7.1.	5	5	4	14	+30%	4.2
5.	Mining	3.2.	3	2	3	8	-50%	-4
6.	Garbage and solid waste	9.4.	2	3	2	7	-10%	-0.7
7.	Utility and Service Lines	4.2.	1	1	1	3	0	0
		Total	28	28	28	84		11.09
						TRA INDEX		13.2

The TRA Index demonstrates a moderate 13.2% reduction since 2013, which reflects the mitigation of three of seven identified threats. Despite considerable reduction (+49%), ‘hunting’ still presents the top threat followed by ‘fishing’ that has worsened (-50%) and ‘invasive alien species' that has been significantly mitigated (+70%). 'Mining' and 'garbage and solid waste' are both identified as worsening threats, sourcing from outside the park. Lastly, 'utility and service lines' in the park do not present a serious problem and the impact of the threat has remained the same since 2013.

4.3.2 GIS Results

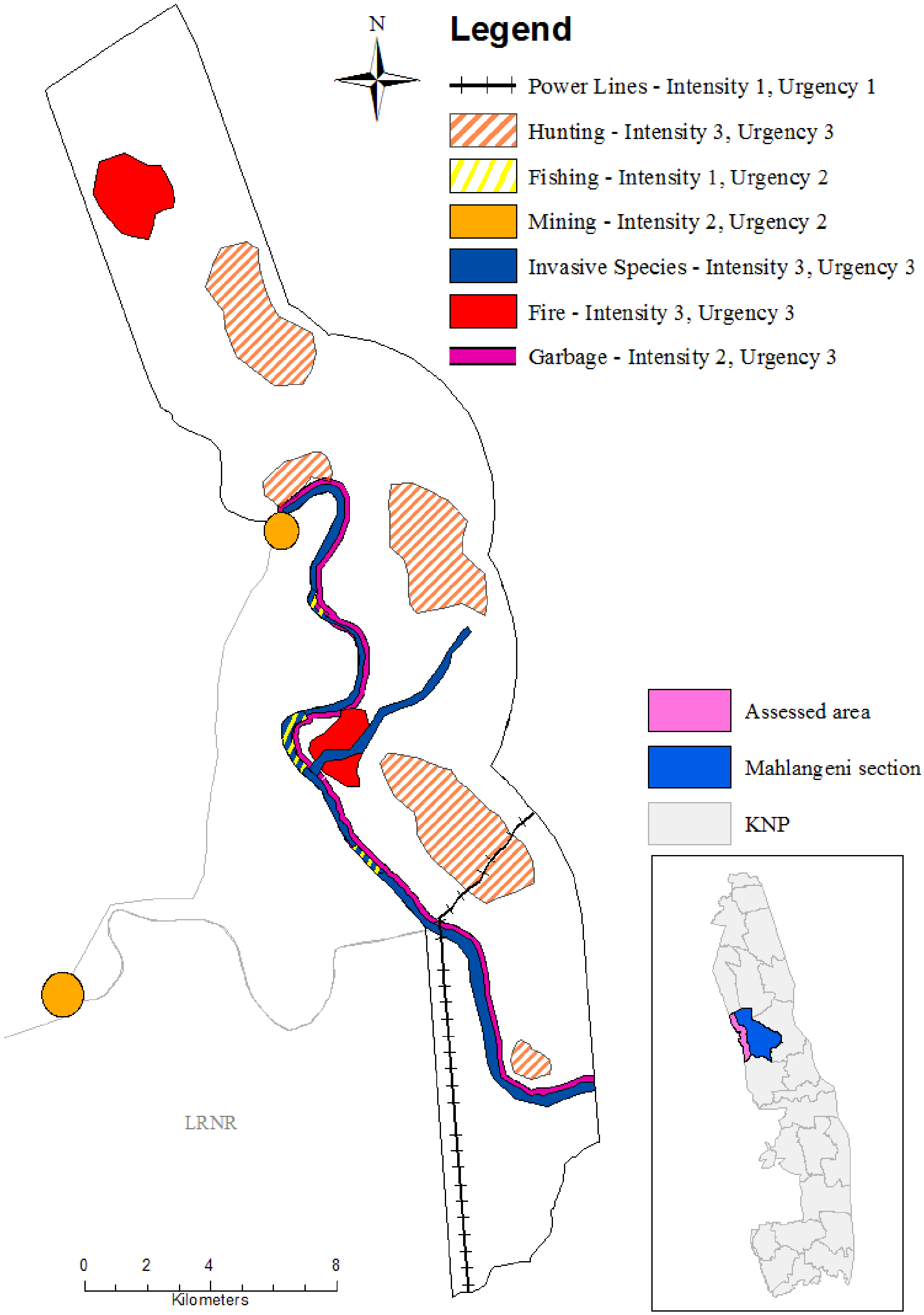

Figure 8. Threats to Mahlangeni's biodiversity in 2013.

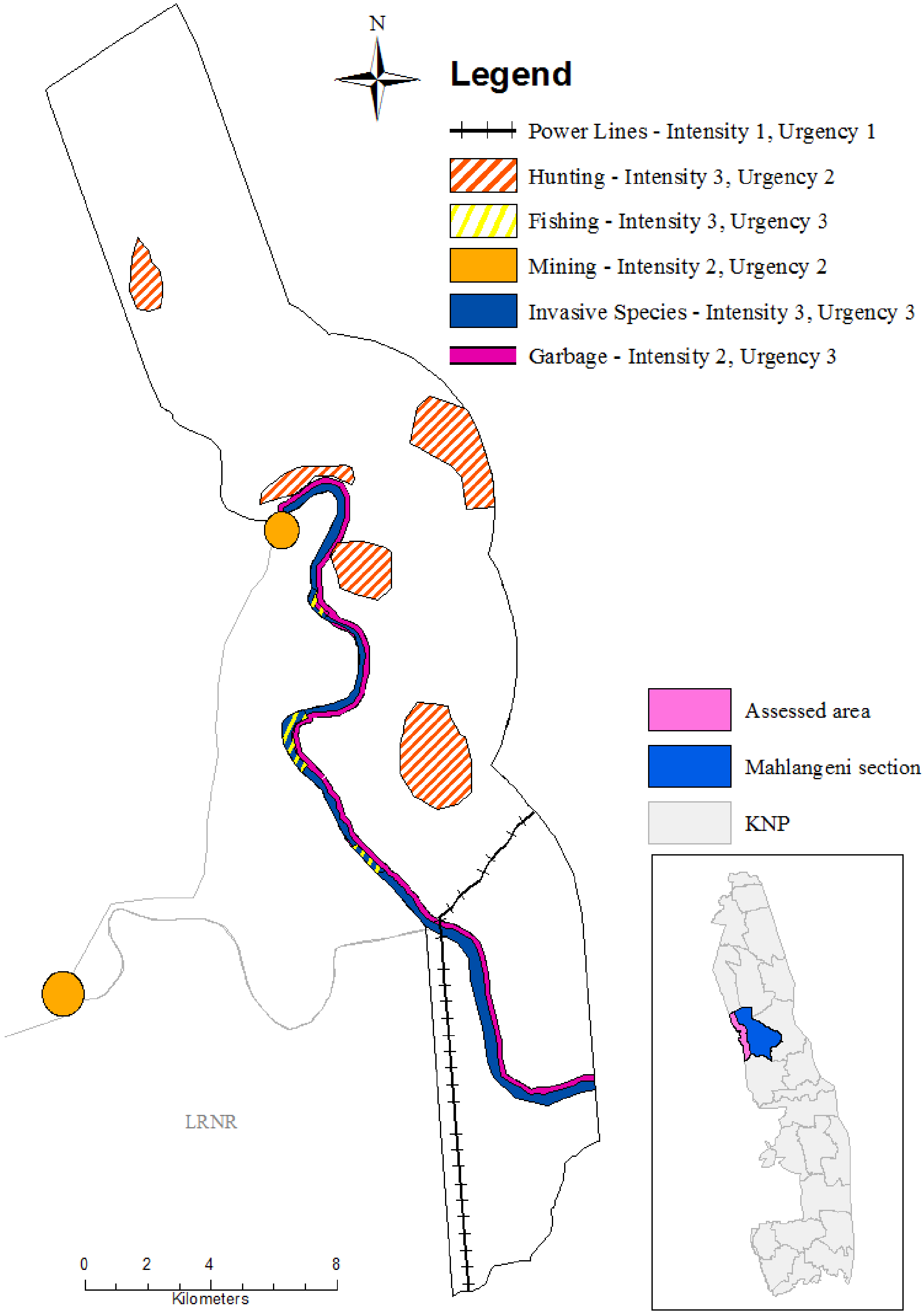

Figure 9. Threats to Mahlangeni's biodiversity in 2017Absence of fire on the map does not mean the threat has been eliminated, but that there were no incidence in 2017 so far.

4.4 Phalaborwa section

4.4.1 MTRA workshop results

The workshop in Phalaborwa was the most demanding one, due to the large number of participants and the absence of the section ranger. The workshop was conducted in the staff village of the Phalaborwa section and attended by twelve field rangers. Participants' experience varied, ranging from 15 to only one year which does not fall necessarily into the criteria for participant selection. However, they were allowed to participate as their potential contribution to the discussion about current threats was recognised by other participants. The section ranger was given a chance to contribute to the assessment via email after the workshop.

Management staff identified five threats. 'Hunting' and 'Fire' have been reduced significantly; however, 'hunting' still remains the top threat. 'Air pollution' from the adjacent Phalaborwa mine has remained the same, and so has pressure from 'utility and service lines'. On the contrary, the problem of 'invasive alien species' has worsened and was given a score of -200%, which is reflected in the final TRA Index of -14.67% (Table 6).

Table 6.Threat Reduction Assessment Index for Phalaborwa section of KNP

No.	Threat	IUCN threat code	Ranking Criteria			Total Ranking	% Threat Change	Raw Score
			Area	Intensity	Urgency			
1.	Hunting	5.1.	5	5	5	15	+60%	9
2.	Invasive alien species	8.1.	4	3	4	11	-200%	-22
3.	Fires	7.1.	1	4	3	8	+80%	6.4
4.	Utility and Service Lines	4.2.	2	2	2	6	0	0
5.	Air pollution	9.5.	3	1	1	5	0	0
		Total	15	15	15	45		-6.6
						TRA INDEX		-14.67

4.4.2 GIS Results

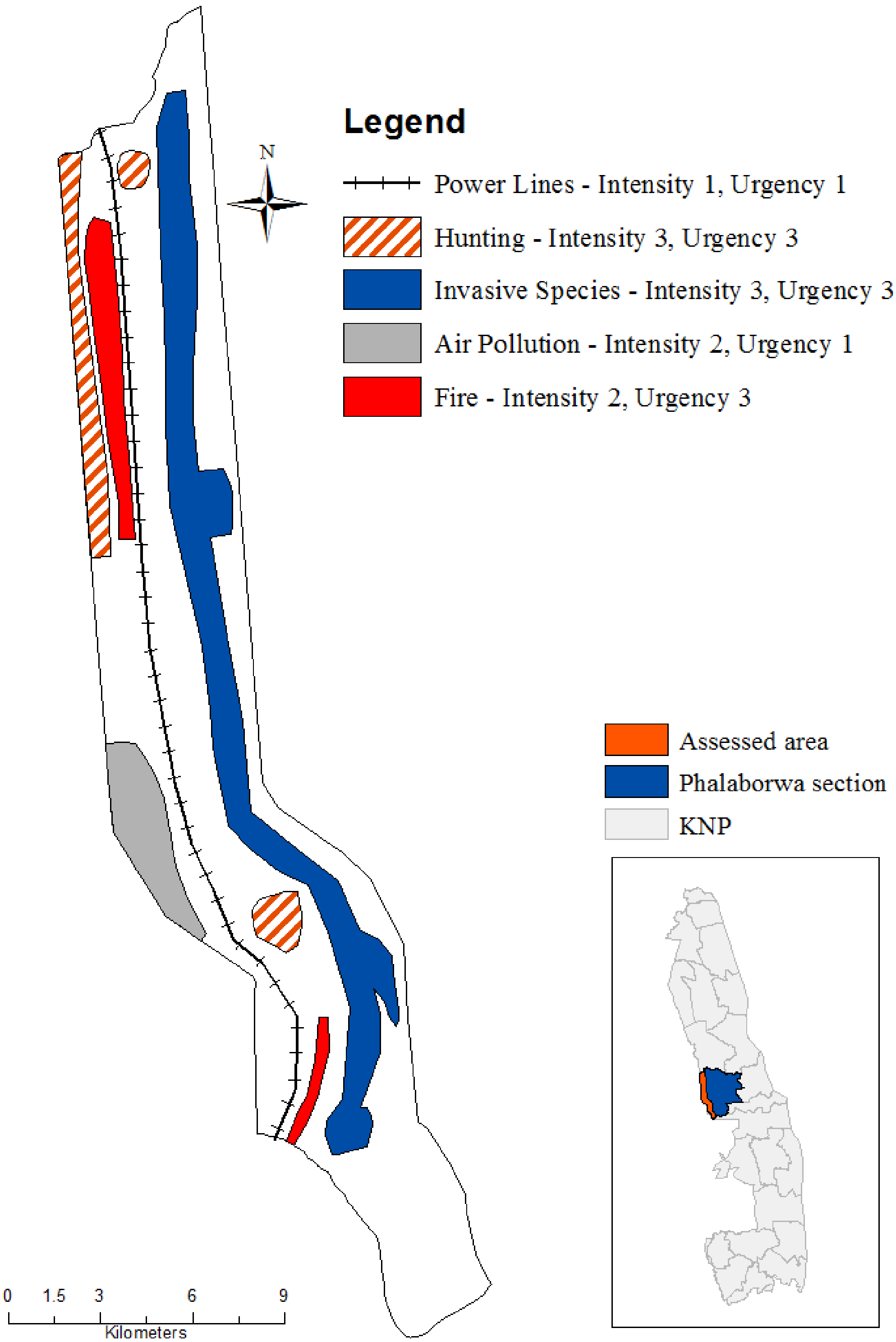

Figure 10. Threats to Phalaborwa's biodiversity in 2013.

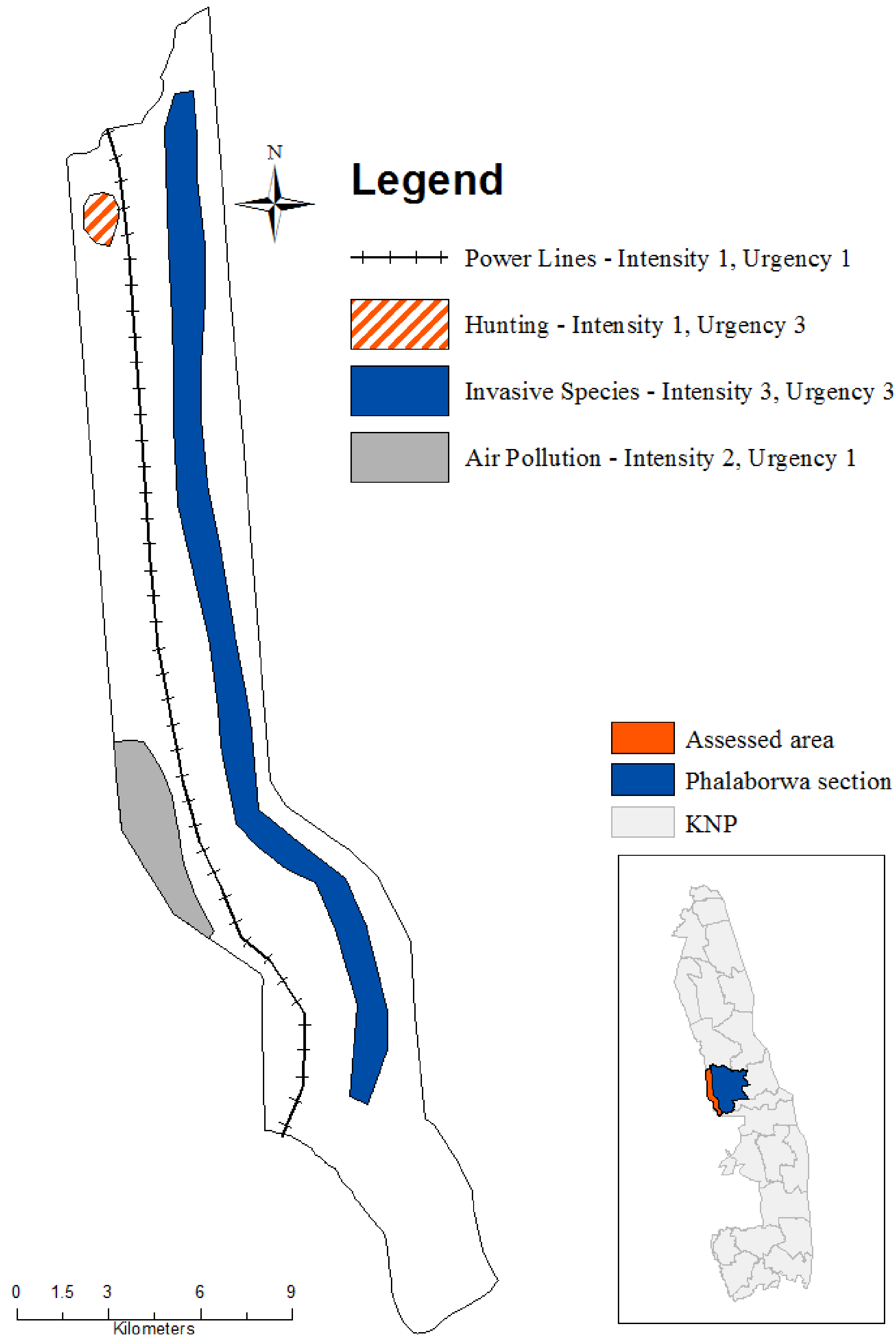

Figure 11. Threats to Phalaborwa's biodiversity in 2017.Absence of fire on the map does not mean the threat has been eliminated, but that there were no incidence in 2017 so far.

4.5 Interpretation of threats and discussion

There are a number of threats that were identified in more than one site (Table 7). The following section attempts to analyse common threats in light of their spatial organisation, in order to better understand their source(s) and reasons for change.

Table 7. Identified threats during all three MTRA workshops.

IUCN threat code	Threat	LRNR	KNP		Total Sites
			Mahlangeni	Phalaborwa	
5.1.	Hunting and collection of terrestrial animals	x	x	x	3
8.1.	Invasive alien species	x	x	x	3
7.1.	Fire and fire suppression		x	x	2 (only KNP)
4.2.	Utility and service lines		x	x	2 (only KNP)
9.4.	Garbage and litter	x	x		2
5.4.	Fishing	x	x		2
3.2.	Mining	x	x		2
11.2.	Drought	x			1
5.3.	Wood harvesting	x			1
8.2.	Problematic native species	x			1
9.3.	Agricultural effluents	x			1
7.2.	Dams	x			1
9.5.	Air pollution			x	1
TOTAL	**13**	**10**	**7**	**5**	**22**

4.5.1 Common threats

4.5.1.1 Hunting

'Hunting and collection of terrestrial animals' was recognised in all three sites as the top threat. In LRNR, the management team included poaching, commercial hunting activities and hunting quotas that are given to the communities of Mthimkhulu and Majeje into the category. Poaching has been identified as the dominant threat in the reserve with most of the illegal hunting being done by poor communities adjacent to the reserve, who hunt for bushmeat as a source of food or, very seldom, as a source of income. Most of the subsistence poaching is done using snares, targeting impala (*Aepyceros melampus*), kudu (*Tragelaphus strepsiceros*) and buffalo. There have been several incidents of poachers being killed by wildlife inside the reserve: in May this year, two men were killed by a buffalo in MNR (pers.comm). Other than for bushmeat, many poachers target elephants and rhinos in the reserve, knowing that the fence between KNP and LRNR has been removed and animals can move freely from one to the other. Rangers in LRNR conduct at least two daily patrols, including three types of patrols: by foot, vehicle or ambush during which they have the authority to arrest any trespassers they spot. The minimum positive reduction of 5% of the threat has been ascribed to the increased frequency of patrols.

Apart from poaching, hunting quotas given to the communities present a threat as they are not being set in accordance with scientific research and are often unsustainable, which is also identified as a challenge in the LRNR Strategic Plan (LEDET 2013). In addition, irregularities concerning issuing of quotas and hunting rights have been investigated by the Letaba Herald (2015a), a local newspaper and EMS Foundation, which published its findings in a report prepared for CITES CoP 2017 (EMS Foundation 2016). Both sources list individuals being involved with reselling of hunting rights in a network underpinned by corruption in the reserve. No official statements regarding the issue were made by LEDET and these claims are based on grey information. However, it is important to keep this in mind to understand the context in which the reserve is being managed. Lastly, commercial hunting activities are not currently well developed and their impact is very limited, but are likely to be increased so the management team decided to include it into the assessment.

As hunting is strictly prohibited in KNP, the rangers in Mahlangeni defined ‘hunting and collection of terrestrial animals’ only as poaching and illegal collection of terrestrial animals. Specifically, poaching for bushmeat, ivory, rhino horns and vulture poisoning is present in the reserve. Poisoning of vultures is carried out either for their body parts that are believed to give clairvoyance ability if eaten, or by poachers as a strategy to minimise detection of the location of poached carcasses to park management authorities. The management team also mentioned that illegal harvesting of mopani worms (*Imbrasia bellina*) is present in the section. In the Phalaborwa section, management staff defined rhino poaching as the dominant threat. In both sites the threat has been reduced by almost half in Mahlangeni and by 60% in Phalaborwa.

KNP has a strong anti-poaching system sometimes described as green militarisation (Lunstrum 2014) which came as a response to the increased rhino-poaching, especially along the eastern boundary of the park. Anti-poaching measures can be considered analogue to war strategies which is mainly reflected in the recent deployment of South African National Defence Force (SANDF) troops that patrol Kruger jointly with the rangers through an operation called Operation Rhino (Lunstrum 2014). SANParks also employed additional 150 rangers who received military anti-poaching training (Lunstrum 2015) and partnered up with couple of military firms that provide equipment needed for anti-poaching activities, such as drones and helicopters with night vision ability (Lunstrum 2015). A paramilitary Environemental Crime Investigation (ECI) Unit was formed to provide intelligence support and the retired Army Major General was hired in 2012 to coordinate anti-poaching efforts in KNP. (Lunstrum 2015; SANParks 2017a). Field rangers patrol their respective sections on a daily basis on foot, by vehicle or by bicycle.

In addition to the anti-poaching measures, the reduction of the threat in both sections can be explained by the fact that there are far less rhinos in the area than in 2013. Of course, rhinos are not the sole target, but most of the poachers that come into the park are after them and according to both management teams, the number of poachers recorded in the area decreased together with the number of animals. Another factor that plays a role is that many poachers come into KNP from Mozambique, at the eastern boundary of the park, so in order to reach the section, they have to spend several days in the park which increases the risk of getting caught or killed.

In addition to the MTRA workshop results and discussion with rangers, geospatial threat modelling results illustrate a potential pattern that could help understand the poachers' entrance points into KNP . In Mahlangeni, areas in which poaching incidents were recorded are prevalent in the southern portion of the assessed area, which is the section where KNP borders LRNR (Figures 8 and 9). Similarly, the Phalaborwa management team identified a high-intensity poaching zone in the very north of the section, which is again sharing the border with LRNR (Figures 10 and 11). It is important to remember that these are the portions of KNP border where the fence has been removed so access to the park is open to anyone trespassing in LRNR. Thus, it is possible that a number of poachers targeting elephants or rhinos are not even attempting to poach inside the reserve, but only use it as an entry point to gain access to KNP. These results suggest that the poaching incidents within Mahlangeni and Phalaborwa are partially a result of poor management practices and law enforcement within LRNR.

4.5.1.2 Invasive alien species (IAS)

IAS have been recognised in all three sites as one of the top five threats, with the situation being improved in the LRNR and Mahlangeni, but worsened in Phalaborwa. In KNP, the first record of alien plant species dates back to 1937, when six species were listed as 'troublesome' (van Wilgen *et al.* 2017). Since then, there has been a dramatic increase in number of alien species found in the park, which grew together with the development of camps and staff villages needed for tourism and management (van Wilgen *et al.* 2017). Due to its position in five major river catchments, the development around (especially activities to the west of KNP), present another source of IAS as rivers provide a continuous inflow of plant material into KNP (SANParks 2008). More and more alien species have been brought into the park either unintentionally by tourists, intentionally by the park's staff as ornamental plants or simply by the river flow from the surrounding land. In Mahlangeni most of the IAS identified by the management team are plants in the riparian zone, which with its periodic flooding represents an ideal habitat for establishment of IAS. Riparian IAS were recognised as a threat since they directly compete for resources with native species, but germinate far more quickly after floods. In Phalaborwa, some portion includes riparian alien vegetation, but large patches of alien vegetation in terrestrial areas have emerged since 2013 and the threat has been identified as two times worse than at the beginning of the assessment period. In LRNR, the extent and the intensity of species invasion is not as well researched as in KNP, but as shown in the threat maps, there are several known patches along the Groot Letaba River. Rangers in both sections defined the 100% threat reduction as complete eradication of IAS.

Due to their proximity and equal environmental conditions, all three sites share the same IAS. In a survey done at the LRNR-KNP boundary in 2009, 29 species were recorded (pers.comm.), some of them being: *Xanthium strumarum*, *Acanthospermum hispidum*, *Malvastrum coromandelianum* and *Alternanthera pungens.*

Both PAs recognise the problem in their management and strategic plans (KNP and LRNR, respectively), although KNP has a much better defined mitigation programme. The control of IAS in LRNR is done on an *ad hoc* basis (LEDET 2013) with the management staff allowing growth during the rainy season and then manually harvesting or cutting them during the dry season to prevent future expansion. According to the threat reduction percentage, this has been a somewhat successful strategy as the problem has been halved since 2013. However, rangers blamed lack of human capacity for tackling the problem, lack of knowledge about the biology of certain species and constant inflow of new seeds and propagules by the river from outside the park to the ongoing problem.

KNP's management plan has a much better formulated IAS programme, based on a hierarchy of objectives, the main being to "*anticipate, prevent entry and control IAS where possible*", organised around five elements: *strategy and support, prevention, control, research* and *awareness* (SANParks 2008). Furthermore, SANParks hold a corporate policy for IAS that outlines these objectives, as well as the KNP Alien Species Standard Operating Procedure and a KNP Standard Operating Procedure for ornamental alien plants in developed areas, which lays out rules about the use and control of ornamental plants in staff residencies and tourist facilities. What all this essentially means is that the prevention and control measures are being decided after well-monitored and researched information has been collected. This is further enabled by the growing use of GIS in monitoring of IAS. In addition to SANParks efforts, most of the plant IAS control in and especially around the KNP is done by the Working for Water Programme, a governmental environmental programme which has invested more than R20 million in KNP until 2003 (REF).

Considering the above, Phalaborwa MTRA results are surprising. Rangers ascribed the -200% worsening of IAS to staff shortage in the section, claiming that there is not enough people who are dealing with the issue through seasonal cutting. They also noted that there are a number of new species invading the section, including the Indian myna (*Acridotheres tristis*) bird. SANParks is currently working with the Society for the Prevention of Cruelty to Animals (SPCA) in Phalaborwa and with the Working for Water Programme to find a solution to the problem of eradicating the birds in Phalaborwa Town. In Mahlangeni, the threat has seen a positive reduction of +70% which rangers attribute to successful control done in the same manner as in LRNR. However, the geospatial threat modelling from Mahlangeni does not reflect this reduction, as the urgency and the intensity of the threat was described as high in both years and the area of the threat has not shrank by that percentage (Figure 9). The discrepancy between the MTRA and geospatial modelling results might imply that the rangers either overestimated the reduction percentage, or have a poor ability of spatially describing the threat.

4.5.1.3 Fire and fire suppression

Runaway 'fires' were identified as a threat in both sections of KNP. Rangers recognised its integral role in shaping and maintenance of savanna ecosystems, but only as long it is managed, so 100% threat reduction was defined as a total elimination of only uncontrolled fires. However, as KNP is surrounded with numerous villages who use fire in their daily lives and that, due to the already dry nature of the local vegetation, fires can easily spread into the park. These unplanned, runaway fires not only threaten the current biodiversity of the park, but also interfere with the park's prescribed burning plans which affects the future state as well.

KNP has a long history of fire management policies that have evolved into today's adaptive fire management based on thresholds, or the previously mentioned TPCs (see section 2.3.5.). The park is divided into 22 large fire management units (FMU) and six small FMU, each of which is administrated by a ranger. In brief, after the assessment of the grass condition is done in autumn, a target of how much should be burnt in each unit is set. Over the next couple of months, rangers start patch mosaic fires to reach the target. During the high-lightning season in September, patches are still available for lighting fires to perform their ecological role (Trollope *et al.* 2003). Considering that the threat recognised in the studied area is human-induced and sourced from outside the park, bordering sections like Mahlangeni and Phalaborwa require additional management interventions. The positive 70% reduction in fires since 2013 in Phalaborwa has been ascribed to the construction of buffer roads between the communities and the park, as well as the more frequent cutting of dry bush within the assessed area. In Mahlangeni, rangers could not identify any particular cause of the 30% reduction. However, considering the threat map from 2013 in Mahlangeni and Phalaborwa, it is surprising that the management team in LRNR has not identified fire as a problem. One of the areas where incidents of runaway fires was recorded in Mahlangeni is bordering the MNR part of LRNR, suggesting that the source of the fire must have been inside the reserve. Similarly, one of the illustrated fire patches in Phalaborwa section is immediately adjacent to the LRNR border (Figure 10).

4.5.1.4 Power and utility service lines

Power lines have been constructed along the western boundary in KNP. Within the assessed 5 km border zone of the sections, there is no tourist infrastructure so the power line network is not as intensively developed as in the southern part of the park, and only brings power to section offices and staff villages. However, it has been recognised as a threat by management teams in both sections, since incidents of wildlife fatality have been recorded. In the majority of cases, the rangers find electrocuted birds, but a giraffe, an elephant and a buffalo were also killed in these two sections since 2013. Electrocution of large game species could potentially be due to some animals using the poles as scratch posts leading to structural damage and falling to the ground, exposing live wires. Some bird species, particularly vultures, use pylons as their nesting sites, while others use it for resting, increasing the risk of being electrocuted. Given this, the management strategy in place is frequent maintenance of the poles and building of landing sites for birds. Rangers identified no change in the threat and acknowledged that while it is impossible to eliminate the power lines from the park, the 100% reduction of the threat would be to not further expand the network.

4.5.1.5 Garbage and Solid Waste

Litter and solid waste have been recognised as a threat in two sites, the LRNR and Mahlangeni section of KNP. It is identified as threating for wildlife, which may get entangled in waste or die from consuming it. In LRNR, garbage is being dumped across the fence into LRNR by neighbouring communities, which is clearly illustrated in the produced threat map. Only the southern part of the reserve is being affected, probably because the fence is more easily accessible from the road that runs along the border. Rangers try to collect the garbage as much as they can during their patrols, but this is not a priority. In Mahlangeni, solid waste is brought into the section by the Klein Letaba River from outside the park. During the dry season, when the management staff starts eradicating IAS around the river, they also collect deposited garbage.

4.5.1.6 Fishing

'Fishing and harvesting aquatic resources' also falls under the 'biological resource use' category of the IUCN threat lexicon (Salafsky *et al.* 2008) and includes illegal extraction of resources in rivers within the boundaries of PAs. It has been identified in two of the assessed sites, LRNR and Mahlangeni section of KNP. The incidents have been observed along both Groot and Klein Letaba rivers using traditional fishing techniques, with fishing rods and fishing nets. In both sites, management staff is allowed to fish in a controlled, sustainable manner as a recreational activity. During the workshop in Mahlengeni, rangers said that "*they enjoy relaxing and fishing by the river during their breaks, as there is not much to do in the park when we are not patrolling*" (pers.comm). Given their attitude, it is not surprising that in both sites the 100% threat reduction was defined as 'reduction of all fishing done by the community, but not by the management staff'. In both sections, the main management strategy to combat illegal fishing is the same as for poaching: conducting frequent patrols. Considering the increased anti-poaching measures in KNP, it is surprising that the management team in Mahlangeni recognised it as a worsening threat. This might be explained by the geospatial data gathered in LRNR. Discrepancy in geospatial data from two sites is interesting: maps in Mahlangeni shows that the fishing activities only take place in portions of the river where the distance from the LRNR fence is the shortest, suggesting that people accessing the reserve do not walk far and lowering the risk of being caught while trying to exit. On the other hand, LRNR rangers indicated no specific areas where fishing was prevalent and spatially defined the threat as present along the entire length of the rivers flowing through the reserve. However, the intensity of fishing has increased from medium to high since 2017, showing that more people decide to fish inside the boundaries of the reserve.

4.5.1.7 Mining

Sand 'mining' has been identified as a newly emerged threat in LRNR and as a worsening threat in Mahlangeni. It has been defined as a threat causing soil erosion and river degradation by altering the sedimentation of the river, which has negative consequences for the biodiversity of the two PAs. Both teams defined the 100% reduction as total elimination of any mining activities.

In Mahlangeni, rangers identified two sand mines on the banks of the Groot and Klein Letaba Rivers, which increase the amount of sediment in rivers flowing into the park. What is interesting is that LRNR management team has not mentioned these two mines, but only one within the reserve's boundaries that was opened in 2014. The reason for this may be that the mine is more prominent in their memory, since it has caused a great amount of controversies since its opening. In 2015, the local newspaper (Letaba Herald 2015b) published a video filmed by a local who drove into the reserve after noticing that the gate was open and there was light during the night. Allegedly, the mine is operating without any permit on a portion of the reserve which was claimed back by the Majeje, Selwane and Makhuva communities, which have all filed complaints about the mining operations to LEDET and to the Department of Rural Development and Land Reform (DRDLR). Although this information is not verified and supported by anything other than a local newspaper and a report by the EMS Foundation (see 4.5.1.1.), it suggests that there are issues with law enforcement in the reserve. When the rangers were asked about this issue they said they were not familiar with any illegality concerning the operating mine.

4.5.2 Other threats

4.5.2.1 Drought

Although droughts are not directly human-induced, their increase in intensity and frequency is believed to be a result of ongoing climate change, which is in part caused by humans (van Loon *et al.* 2016), so the LRNR management staff decided to list it. The reserve was hit by a severe drought in 2014, which has severely damaged both the vegetation and the fauna of the park, by causing river and waterholes to dry out. According to the rangers, such events are highly anticipated but the mitigation strategies are not being developed or discussed, as current, more urgent threats, are being prioritised.

4.5.2.2 Wood harvesting

Although there is no commercial logging and large scale wood harvesting in LRNR, occasional wood harvesting still presents a threat in the reserve. The primary source of the threat are local community members who trespass into the reserve to collect firewood for cooking or heating. Biomass is the main source of energy in over 80% of households in sub-Saharan Africa with many communities being entirely dependent on firewood, or even if connected to the grid, still using it for cooking (Wessels *et al.* 2013). In a more proximate study, Anthony (2006) estimated the use of fuelwood by 38 rural communities bordering the north of the study area. He found that 93.3% of sampled households harvested local fuelwood, utilising 0.3 m^3 weekly. The demand is the highest in poor areas where unemployment rates are high and wood harvesting is seen as an opportunity to be paid by fellow members of the community. Uncontrolled removal of dead material from the soil surface alters its productivity and interferes with bio-geophysical cycles, thus threatening ecosystem integrity.

Rangers identified the threat as present along the borders of the reserve where the community is collecting dead wood from the ground. This is supported by the geospatial data which shows that the high intensity areas are portions of the border that are nearest to the adjacent villages of Mbaula and Phalubeni. The threat has been halved since 2013, which the rangers attribute to the growing number of community outreach and poverty reduction programmes in the area. The reserve's staff also collects the surplus of dead tree material, when present and gives it to the community.

4.5.2.3 Problematic native species

The management team in LRNR identified bush encroachment caused by 'problematic native species' as a growing problem in the reserve. The bush encroachment is increase in density, cover and biomass of woody vegetation, such as tree and bush species, at the expense of the grass layer in the savanna. Although the cause of it is not entirely understood, studies attribute it to overgrazing, increased rainfall, fire suppression or soil composition (O'Connor *et al.* 2012). In LRNR, rangers explained the worsening of the threat by -200% as a result of overgrazing and no management strategy in place, e.g. fire management.

4.5.2.4 Agricultural effluents

Water pollution from the surrounding cropland has been identified as an increasing threat for the Groot Letaba River ecosystem. A portion of the catchment between Tzaneen and KNP has been the most ecologically modified section of the river, with the range of pressures coming from constructed dams and intensively developed agriculture. The quality of the water is altered by the fertiliser runoff that increases the concentration of nutrients in the water, thus stimulating growth of algae and aquatic plants which eventually can reduce the amount of oxygen available in the water. According to the management team, the increase in mitigation could be potentially ascribed to a more detailed monitoring of the water in the reserve.

4.5.2.5 Dams and waterholes

Artificial 'dams' and waterholes have been identified as threat in LRNR as they generally attract more animals, including herbivores, that cause overgrazing around it and ultimately soil erosion. There is a number of seasonal dams located south from the Groot Letaba River (LEDET 2013) and about 11 waterholes, as shown in the threat map. The management team acknowledged the need for these, especially considering the anticipated temperature rise and decrease in rainfall, but determined the current number of waterholes as sufficient for reserve's needs and that 100% threat reduction would be zero future construction.

4.5.2.6 Air pollution

Air pollution has been identified as a threat in the Phalaborwa section of KNP that has remained the same since 2013. The pressure stems from the operating copper and phosphate rock mines in the adjacent town of Phalaborwa, which is the main income source for the majority of its inhabitants. Apart from purely extracting copper, the copper mine also operates a smelter and a refinery complex in Phalaborwa, producing approximately 45,000 tons of copper per year (PMC 2017). The section rangers determined air pollution resulting from these activities as threating for the biodiversity in KNP, as the particles emitted in the air from the mine are being brought by wind into the park and are deposited on the park's vegetation and soil. This may alter primary production, soil quality and ecosystem functioning of the park. In fact, studies have been done on the effect of the mine's smelting operations on the herbivores in the park finding levels of copper in both their respiratory and digestive organs, which has been attributed to air pollution (Gummow *et al.* 1991; Grobler and Swan 1999).

There are no mitigation strategies that can be implemented solely by SANParks. Therefore, it was very difficult for the Phalaborwa management team to come up with a 100% threat reduction definition. After a long discussion, they decided to define it as total elimination of air pollution, which would almost certainly require the closure of the mines. According to them, the situation is still tolerable and such radical measures are not necessary yet. However, enhanced cooperation between the mines and SANParks should be established, in order to find a way to mitigate the threat as much as possible.

4.5.3 Additional management challenges

In addition to the discussed threats, the research revealed supplementary factors that are proving to be an obstacle in management of the assessed sites. These factors will be briefly discussed in the following paragraphs.

4.5.3.1 Governance

Governance presents a dominant issue in LRNR, particularly in the northern MRNR part. According to the strategic plan (LEDET 2011), that portion of the reserve should be managed jointly with the Mthimkhulu community and a co-management agreement was being drafted in 2013. However, during the MTRA workshop it was revealed that the management staff from LRNR holds a strong opinion that it is, and should only be them managing the entire area and no mention of the agreement or any sort of cooperation between LEDET and the community was made. On the contrary, guards assigned by the community Chief are positioned at the three entrance gates in MRNR with the purpose of obstructing the LEDET's work. They hold no official qualifications; there were selected solely based on their willingness to do the job (pers.comm.). According to one of the interviewees, they do bike patrols through the reserve and inform the community-assigned reserve manager if they come across something (pers.comm.). The conducted interviews suggest that the community is not benefitting from the reserve at all; hunting quotas are non-existent at the moment and they do not receive any other sort of compensation. This has severe implications for the management of the reserve in two ways. Firstly, community based threats to the biodiversity identified during the MTRA workshop are partially the result of community's dissatisfaction. As they are not participating in the management of their own land and are denied benefits from it, they do not feel the need to protect it and will continue trespassing and taking what they feel it belongs to them (pers.comm.). Secondly, present management interventions in place at LRNR cannot achieve long-term conservation success as long as the community is obstructing LEDET's work. Community support is needed for conservation to succeed and more inclusive model should be implemented in LRNR.

4.5.3.2 Staff shortage

Second problem that was raised during workshops in all three sites is staff shortage. Particularly in Phalaborwa, management staff attributed the -200% worsening of IAS to lack of people dealing with the problem. The increase in area of IAS requires a higher number of rangers.

4.5.4 Conclusion

The selected methodology was sufficient to fulfil the aim of the research. Across three sites, 13 threats were identified in total, some of which were shared among multiple sites. The negative TRA indices of -14.67% in Phalaborwa and -33.6% in LRNR show that the overall threats have worsened since the 2013, while the positive +13.3& TRA Index show that the situation in Mahlangeni has improved. Top threats identified during the workshops include hunting and collection of terrestrial animals and invasive alien species. Using the data gathered through records review, discussion during the workshops and informal interviews with local stakeholders, the threats were interpreted and compared across sites. Geospatial data helped to understand the source of the threats; results imply that inadequate management of LRNR also negatively impacts the bordering KNP sections, by providing access points for poachers and runaway fires to KNP. In all three sites, the tool can be used in the future for monitoring the management effectiveness, while the results can be used in prioritising management actions.

5. Conclusion

5.1 Introduction

This chapter summarises the main research findings, illustrates how the utilised methodology fulfilled the research aim and objectives and provides recommendations for future application of the tool, as well as for the future research in the area.

5.2 Fulfillment of the research objectives

The aim of the research was to identify the nature of threats to biodiversity in the LRNR and selected sections of KNP. In order to achieve the aim, several objectives were set. After reviewing the available literature, the MTRA tool was selected as the most suitable one. Using the selected MTRA method, the research revealed total of 13 threats across three sites, with multiple threats being identified in more than one site. Threats were ranked according to their area, urgency and intensity and a percentage of change was assigned to each of them. This was required to calculate the TRA Index in each site, which represents the overall change in threats to biodiversity in the area. Threats and their change were spatially described using GIS based on the geospatial data collected during the MTRA workshops. Lastly, the results were compared across the assessed sites by using the background information collected through records review, discussions during workshops and produced threats maps.

TRA Indices show a negative values of -33.6% in LRNR and -14.67% in the Mahlangeni section, and a positive reduction of 13.2% of threats in Phalaborwa section of KNP. Considering the proximity and similar physical and biological features of the sites, most of the threats were identified in more than one site. The top threat identified in all three sites is hunting and collection of terrestrial animals, which predominantly includes poaching for bushmeat, ivory and rhino horn.

Invasive alien species were also recognised as a highly ranked threat in all sites: rangers identified the riparian alien vegetation as the biggest portion of the threat. Other threats, shared by only two sites, are fishing, runaway fires, garbage and solid waste, mining and power lines. Threats identified only in one of the sites are wood harvesting, drought, problematic native species, agricultural water pollution, air pollution and dams. Most of the identified threats are community-based threats and partially stem from the community's dissatisfaction with the LRNR's management, as revealed through informal interviews. Management interventions in all three sites are focused mostly on preventing trespassing through frequent patrols and enforcement of the law in order to mitigate multiple threats. Threat maps, when combined with the data collected through MTRA, imply that the relatively poor management effectiveness in LRNR is negatively impacting biodiversity not only within the reserve, but also in KNP. Poaching and runaway fire incidents in KNP were identified in the bordering zone with LRNR, which suggests that the source of the threat is in LRNR. However, further research is needed to validate these results.

5.3 Suggestions for future research

Considering the scope of the study and the encountered limitations, there are several recommendations for future application of the tool as well as for general research in the area that should be noted.

Recommendations concerning the application of MTRA:

- When administering the tool, it is vital to keep everyone's attention during the workshop and make sure everyone present is participating. Very often, the superior ranger might dominate the discussion and this should be prevented;
- High number of participants is desired, as long as their superior is also present;
- It is important to anticipate reluctance from the potential participants when organising the workshops and plan your timeframe accordingly.

- During the workshops, it is very important to get as much information as possible as the supporting material might be promised, but never actually provided.

Recommendations for research in the area:

- In order to fully understand the sources of threats, further research about the community perception of LRNR and KNP is needed;
- Additional challenges for the management LRNR and KNP, e.g. funding should be investigated;
- In order to effectively monitor management interventions and subsequent changes in threats to biodiversity, the tool should be applied on a frequent basis.

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Appendices

Appendix A – MTRA Workshop Information Sheet

What is a Modified Threat Reduction Assessment (MTRA)?

All protected areas face threats. Threat Reduction Assessment (TRA) is used to measure biodiversity threats and their changes over time. By measuring threats, it is possible to get an indirect measurement of conservation efforts. TRAs rely on the knowledge and expertise of the management staff, as they know the protected area the best.

When thinking about the biodiversity threats, it is important to keep in mind the three components that constitute biodiversity for the purpose of TRAs:

1. Species present;
2. Habitat condition and the area;
3. Ecosystem functions.

The TRA approach is based on three key assumptions:

1. **All threats to biodiversity are human-induced.** Loss of biodiversity or habitat caused by natural phenomena is not considered a threat (e.g. fires cause by lightning). However, natural threats that have increased in frequency or intensity as a result of human activities, may be included.
2. **All threats to biodiversity can be identified.** Management staff are able to identify, classify and rank all the threats, based on their impact, intensity and urgency in the area.
3. **It is possible to measure or estimate the changes of these threats.** Experts and managers have the ability to determine the percentage of change over a defined period of time.

Modified Threat Reduction Assessment (MTRA) is a modified version of TRA that allows for inclusion of new or worsening threats. It was proposed by my thesis supervisor, Brandon Anthony, and has been conducted for a number of protected areas in Ghana, Lebanon, Mongolia, Ukraine and South Africa (KNP).

Steps of MTRA:

1. ***Define the study in space and time***.

   (e.g. area - Phalaborwa section of KNP, time- decide the target year which the present condition will be compared to)

2. ***Identify all direct threats present at the site, both historically and at present.*** Threats are defined as those human activities that cause some degree of deterioration or destruction of the biodiversity (species, habitats, ecosystem function) in the site. Threats can be divided into:

   a. *Internal Direct Threats:* caused by stakeholders living on site,
   b. *External Direct Threats*: caused by people outside the PA.
   c. *Indirect Threats*: Social, economic and political aspects that provoke direct threats. These are not to be included.

3. ***Define the threats.*** As a group, discuss threats and define each according to the IUCN lexicon of threats categories.

4. ***Define 100% reduction for each threat.*** 100% reduction is assumed to be a complete elimination of a threat.

5. ***Rank each threat for the defined start date, based on the following:***

   a. **Area** – how much of the habitat is affected by the threat?
   b. **Intensity-** how severe is the impact of a threat in the site? Does the threat completely destroy the habitat or just cause minor changes?
   c. **Urgency** – how urgent should the threat be addressed? Is it likely to increase?

6. ***Add the scores to calculate each threat's total rank.***

7. ***Decide how much (%) the threat changed since the chosen start date.***

   a. If a threat was present at the start date and has been reduced, the score will be positive. If it is completely eliminated, the top score is 100%.
   b. If a threat has worsened since the start date, the score will be negative. There is no top line for a negative score so if you think that something has worsened 4 times, that threat can be given a score of -400%.
   c. If a threat was not present at the start date, but has emerged since then, that threat can be given a score of -100%.

8. ***Calculate each threat's raw*** score by multiplying its total rank with percentage of change.

9. ***Calculate the MTRA index*** by dividing the total raw score with the total ranking and then multiplying it with 100 to get a percentage.

10. ***Discuss the reasons behind the changes.*** What were the positive actions taken? Which management strategies have changed since the start date? How is management effectiveness measured in your area?

Appendix B – MTRA Index calculation sheet

Site name:

Site description:

Assessment Period: Completed on:

Completed by:

No.	Threat	IUCN threat code	Ranking Criteria			Total Ranking	% Threat Change	Raw Score
			Area	Intensity	Urgency			
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
		Total						

TRA Index Formula	Total Raw Score		Total Ranking		Convert to %		TRA Index (%)
TRA Index Calculation		÷		=	X 100	=	