Analysis of rhino poaching incidences and management strategies in South Africa

by

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ABSTRACT

The illegal hunting and global trade in wildlife and wildlife products is a transnational, highly organised crime that threatens the survival of many endangered species. The rhinoceros is a well-known example of this trade as the demand for rhino horn for use in East Asia has resulted in the global decline of rhino populations, resulting in the Western Black rhino in Africa (*Diceros bicornis longipes*) officially being declared extinct in 2011. Although poaching has always existed, the number of African rhinos killed by poachers has escalated in the past eight years with at least 1 338 rhinos killed by poachers across Africa in 2015. This is the highest level since the rhino poaching crisis began in 2008, resulting in at least 5 940 African rhinos being killed. The majority of these incidences occurred within South Africa. South Africa plays a leading role in the conservation of the African rhino, currently conserving 83% of the African rhino population. However, it has been suggested that should poaching continue to increase as it has done over the past few years the rhino population in South Africa may begin to decline as early as 2016.

South Africa's upsurge in rhino poaching over the last few years has given rise to a kaleidoscope of debates on how to reduce poaching. An understanding of the different management strategies and their effectiveness would play a large role in identifying which method or combinations of methods work best to reduce poaching. The second chapter of this dissertation thus critically analyses the past, current and proposed strategies that are relevant to reducing incidences of rhino poaching using empirical literature from various scholars and stakeholders and attempts to provide insight into which strategy or combination of strategies is best suited to reduce poaching. As poaching involves a combination of aspects, it is clear that no one strategy or management tool will address all of these aspects on its own, and if implemented in isolation will not be successful. A combination of strategies that address all aspects of poaching needs to be working concurrently to decrease poaching levels.

Law enforcement is one such management strategy crucial in the reduction of poaching and with increasing poaching incidents, law enforcement efforts in the form of deployment of anti-poaching unit, focused on high risk areas would provide for a more efficient and effective use of resources in reducing poaching incidences. The third chapter of this dissertation sought to investigate the spatial and temporal patterns of rhino poaching in the Hluhluwe-iMfolozi Park (HiP) between 1990 and 2013 and examine the relationships between observed patterns of poaching and biophysical and human variables using Geographic Information Systems (GIS). The results reveal poaching hot spots, and spatial and temporal variation in poaching incidences. Biophysical and human variables were also found to influence poaching densities differently depending on where they occurred spatially or temporally. The successful use of GIS in this analysis validates its potential as a geospatial tool for understanding the spatial and temporal distribution patterns of rhino poaching in the HiP. Understanding these patterns is crucial for future anti-poaching planning and mitigation of poaching activities with protected areas.

PREFACE

The work described in this dissertation was carried out in the School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Westville Campus, from July 2013 to December 2016, under the supervision of Njoya Silas Ngetar.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

The articles making up chapter two and chapter three are currently being peer reviewed by the South African Geographical Journal and Geocarto International Journal respectively. Each article can be read independently from the rest of the dissertation but draws conclusions relevant to the work as a whole.

DECLARATION 1 - PLAGIARISM

I, Sade Moneron, declare that

1. The research reported in this thesis, except where otherwise indicated, is my original research.

2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

4. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
   a. Their words have been re-written but the general information attributed to them has been referenced
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5. This thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the thesis and in the References sections.

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DECLARATION 2 – MANUSCRIPTS

1. Moneron SL and Ngetar SN. A critical review of strategies to reduce rhino poaching in South Africa (Paper submitted to the South African Geographical Journal).

2. Moneron SL and Ngetar SN. Analysing the spatial and temporal patterns of rhino poaching in the Hluhluwe-iMfolozi Park, South Africa using GIS (Paper submitted to the Geocarto International Journal).

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CHAPTER ONE

INTRODUCTION

1.1 Illegal trade in wildlife

Globally there is a high demand for wildlife species (both plants and animals) and their products (TRAFFIC, 2008). Wildlife species are used for a variety of reasons including food, fuel, clothing, healthcare, ornaments and religion (Oldfield, 2003; TRAFFIC, 2008). Glaubitz (2015) states that while much of the trade in this wildlife is legal, the hunting and killing of specific endangered wildlife is not. Regardless of its legality, the hunting and global trade in illegal wildlife and wildlife products is an industry estimated to be worth US$50-US$150 billion per year (United Nations Environment Programme (UNEP), 2014). This transnational, highly organised crime continues to threaten the survival of many endangered species globally (Glaubitz, 2015; TRAFFIC, 2008; UNEP, 2014).

The world's five species of rhinoceros (rhino) are such threatened with all five species (three Asian species namely the Indian rhino, *Rhinoceros unicornis*, the Sumatran rhino, *Dicerorhinus sumatrensis*, and the Javan rhino *Rhinoceros sondaicus*, and two African species, the black rhino *Diceros Bicornis* and white rhino *Ceratotherium simum*) appearing on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2014). The illegal hunting (poaching) of rhinos for their horns has resulted in the global decline of rhino populations resulting in the Western Black rhino in Africa (*Diceros bicornis longipes*) officially being declared extinct in 2011 (Emslie, 2011). Furthermore, only three individuals exist for a subspecies of the white rhino, the northern white rhino also known as the *Ceratotherium simum cottoni* (McKie, 2016; Mosbergen, 2016; Pohlman, 2016; Starr, 2016).

Although poaching has always existed, Emslie et al. (2012) maintain that since 2008, rhino poaching has escalated remarkably, with an average 50% increase between 2008 and 2013. In a recent report compiled by the IUCN Species Survival Commission's African Rhino Specialist Group, the number of African rhinos killed by poachers has increased for the sixth year in a row with at least 1,338 rhinos killed by poachers across Africa in 2015 (IUCN, 2016). This is the highest level since the current poaching emerged in 2008, resulting in at least 5 940 African rhinos since 2008 (IUCN, 2016). The majority of the poaching incidents occur within South Africa comprising 87.8% of total rhinos poached in 2015 (Emslie et al., 2012; IUCN, 2016).

South Africa has played a leading role in rhino conservation since the late 1800s when it was thought that the African southern white rhino had gone extinct until a small population of approximately 20 was discovered in the iMfolozi (formerly Umfolozi) region of KwaZulu-Natal (formerly Natal) and given protection (Cumming et al., 1990). Since then, southern white rhino numbers in Africa have grown significantly to over 20 000 ('t Sas-Rolfes, 2012; Emslie & Brooks, 1999). Within South African borders, a record number 20 711 rhinos (83% of the total African rhino population and 73% of wild rhinos globally) are currently being conserved in both private and public protected areas (‘t Sas-Rolfes, 2012 and Emslie et al., 2012). If poaching continues to increase as in the past few years, the rhino population within South Africa may begin to decline as early as 2016 (Emslie, 2012).

The demand for rhino horns by countries such as Vietnam and China are believed to be the main drivers behind the drastic increase in rhino poaching incidences (Ellis, 2005; Milliken & Shaw, 2012; Trendler, 2011). Rhino horns have been used throughout Asia for thousands of years for both ornamental and medicinal purposes including fever and headaches (‘t Sas-Rolfes, 2012). It is recently also being promoted as treatment for cancer (Milliken & Shaw, 2012). Recent studies have shown that the demand for rhino horn in Vietnam is related to social status, citing the main culprits as the influential, well-educated and successful people within the Vietnamese society who value the horn as a symbol of wealth, power, and reassurance of social standing (Caldwell, 2013; Environmental Investigation Agency, 2013; Milliken & Shaw, 2012; Smith, 2012; Tanner, 2015). These among others are considered catalysts for the increased demand for rhino horns, posing a serious challenge to rhino conservation in Africa, and threatening to undermine decades of conservation achievement (Milliken & Shaw, 2012).

1.2 Evaluation of management strategies

To reduce rhino poaching in the field law enforcement is fundamental as rangers on the ground represent the primary deterrent for potential poachers (Critchlow et al., 2016). Although law enforcement is crucial for reducing illegal activities, it represents a significant cost expenditure in many protected areas suggesting that increasing the efficiency of ranger patrol activities should be a priority (Critchlow et al., 2016; Jachmann, 2008; Plumptre et al., 2014). An assessment of the patterns of rhino poaching may provide important insights about areas that are most vulnerable to poaching and thus guide more effective and efficient law enforcement efforts within protected areas (Critchlow et al., 2015; Maingi et al., 2012; Sibanda et al., 2015).

Although the importance of law enforcement in reducing illegal activities such as poaching has been mentioned in various studies (Akella & Cannon, 2004; African Wildlife Foundation, 2014; Critchlow et al., 2015; Critchlow et al., 2016; Hilborn et al., 2007; Maingi et al., 2012; Sibanda et al., 2015), law enforcement cannot act as a stand-alone deterrent for poaching (Challender & MacMillan, 2014). South Africa’s upsurge in rhino poaching over the last few years has given rise to a kaleidoscope of debates on how to reduce poaching.

Whether poaching occurs in a particular population can be considered as a function of reward and risk to a poacher as suggested by Du Toit (2011). Poaching is likely to be reduced by either reducing the reward to the poacher, or by increasing the risk and difficulty associated with poaching (Du Toit, 2011). Several authors have highlighted different strategies aimed at reducing poaching including the legalisation of international trade in rhino horn, demand reduction, dehorning, translocation, law enforcement, local community involvement and political will (specifically in tackling corruption) (Department of Environmental Affairs (DEA), 2013; Duffy et al., 2013; Ferreira et al., 2014; Sollund & Maher, 2015). Reducing poaching is a highly complex and challenging task and it has become evident that no one solution will decrease rhino poaching on its own (Bega, 2015; Guedes, 2016; Milliken & Shaw, 2012). An understanding of the different management strategies and their effectiveness would play a large role in identifying which method or combinations of methods work best to reduce poaching (Cheteni, 2014).

1.3 Study aims and objectives

The aims of this dissertation include analysing the spatial and temporal patterns of rhino poaching within the Hluhluwe-iMfolozi Park (HiP), South Africa to enable for more efficient and effective patrol efforts within the park. An understanding that law enforcement is a management strategy that addresses only one aspect of rhino poaching, this study further aims to critically analyse some of the other proposed management strategies, as well as an evaluation of past effectiveness and finally, considerations if implementation were to occur. The specific objectives of this study are as follows:

1. To investigate how rhino poaching varied seasonally and annually within the HiP.

2. To determine the spatial patterns of poaching incidents within the HiP and in turn identify poaching hotspots.

3. To investigate the relationship between the observed patterns of poaching and biophysical and human variables.

4. To analyse both past, current and proposed management strategies that are relevant in reducing rhino poaching using empirical literature from different scholars.

5. To examine the effectiveness of past and current strategies in reducing rhino poaching.

6. To determine which strategy or combination of strategies is best suited to reduce rhino poaching.

1.4 Limitations of dissertation

Although this dissertation has made reference to statistics relating to rhino poaching in South Africa during 2015, the analysis of spatial and temporal patterns of poaching within the HiP was conducted on rhino poaching incidences between 1990 and 2013. Poaching incident data for 2014 and 2015 for the HiP could not be obtained from the park's management, Ezemvelo KZN Wildlife, for inclusion in this study. Furthermore, display or publication of exact rhino poaching locations has been prohibited by Ezemvelo KZN Wildlife due to the sensitivity and security of the information, and thus no point locations can be displayed in this dissertation.

1.5 Structure of dissertation

This dissertation comprises of four chapters with two chapters conceptualised as stand-alone research articles that address the objectives listed in section 1.3. The first chapter is the introduction of the study, providing the context, the study's aims and objectives as well as a description of the structure of the dissertation. The second chapter contains a literature review and analysis of the past, current and proposed management strategies to reduce rhino poaching in South Africa. Chapter three contains the article which explores the spatial and temporal patterns of rhino poaching which in turn could assist in effective and efficient law enforcement within protected areas. Lastly, chapter four provides a synthesis and conclusion of the research.

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CHAPTER TWO

A CRITICAL REVIEW OF STRATEGIES TO REDUCE RHINO POACHING IN SOUTH AFRICA

Moneron SL and Ngetar SN. A critical review of strategies to reduce rhino poaching in South Africa (Paper submitted to the South African Geographical Journal).

2.1 Abstract

The conservation of rhino is suffering significant setbacks as incidences of rhino poaching for their horn have increased substantially since 2008, particularly in South Africa. This recent upsurge in rhino poaching is a consequence of increased demand for rhino horn in Asian countries and has resulted in a kaleidoscope of debates surrounding best strategies in reducing poaching incidences. This paper critically analyses the past, current and proposed strategies that are relevant to reducing incidences of rhino poaching using empirical literature from various scholars and stakeholders and attempts to provide insight into which strategy or combination of strategies is best suited to reduce poaching. As poaching involves a combination of aspects, it is clear that no one strategy or management tool will address all of these aspects on its own, and if implemented in isolation will not be successful. A combination of strategies that address all aspects of poaching needs to be working concurrently to begin to decrease poaching levels.

***Keywords*:** rhino poaching; anti-poaching strategies; conceptual framework; integrated approach

2.2 Introduction

The rhinoceros (rhino) is currently in the spotlight of biodiversity conservation discourse as the struggle to protect them continues. Five species exist including three Asian species (the Indian rhino *Rhinoceros unicornis,* Sumatran rhino *Dicerorhinus sumatrensis* and Javan rhino *Rhinoceros sondaicus*) and two African species (the black rhino *Diceros Bicornis* and white rhino *Ceratotherium simum*). All five species are listed in the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The Red List of Threatened Species catalogues and highlights species of flora and fauna that are facing a higher risk of global extinction (IUCN, 2014). The global classification of the five rhino species ranges from Near Threatened to Critically Endangered emphasising the need and importance for conservation strategies that are sustainable.

The history of rhino conservation in South Africa extends back to the late 1800s, when it was thought that the African southern white rhino had gone extinct until a small population of approximately 20 was discovered in the iMfolozi region (formerly Umfolozi) of Natal and given protection (Cumming et al., 1990). Since then, southern white rhino numbers in Africa have grown significantly to over 20 000 ('t Sas-Rolfes, 2012; Emslie & Brooks, 1999). In the past few decades South Africa's leading role in ensuring the survival and increase of the African rhino population has resulted in the current conservation of approximately 20 711 rhinos (83% of the total African rhino population and 73% of wild rhinos globally) ('t Sas-Rolfes, 2012; Emslie et al., 2012). However, this success is experiencing significant setbacks due to recent increasing incidents of rhino poaching in South Africa for their horn (Grant, 2014).

In a recent report compiled by the IUCN Species Survival Commission's African Rhino Specialist Group, the number of African rhinos killed by poachers has increased for the sixth year in a row with at least 1,338 rhinos killed by poachers across Africa in 2015 (IUCN, 2016). This is the highest level since the current crisis emerged in 2008, resulting in at least 5 940 African rhinos being killed (IUCN, 2016). Majority (85%) of these poaching incidents occurred within South Africa (Emslie et al., 2012). Although poaching has always existed, Biggs et al. (2013) and Emslie et al. (2012) maintain that since 2008, rhino poaching incidents in South Africa are increasing at an average rate of 50% each year. Poaching incidents reveal that more than three rhinos are killed every day in South Africa (Martins, 2015). If poaching continues to increase like it has year on year, mortality rates will soon exceed birth rates and the rhino population within South Africa will begin to decline (Emslie, 2012).

Although rhino horn consists only of keratin, calcium and melanin, demand for rhino horns by countries such as Vietnam and China are believed to be the main drivers behind the drastic increase of rhino poaching incidences (Ellis, 2005; Milliken & Shaw, 2012; Trendler, 2011). Rhino horns have been used throughout Asia for thousands of years for both ornamental and medicinal purposes ('t Sas-Rolfes, 2012). Historically, rhino horn in Asian countries is associated with the treatment of various ailments including fever, headaches, measles, epilepsy and stroke (Milliken & Shaw, 2012). It is also being promoted as treatment for various life-threatening diseases such as cancer (Milliken & Shaw, 2012).

Studies show that the demand for rhino horn in Vietnam is related to social status, citing the main culprits as the influential, well-educated and successful people within the Vietnamese society who value the horn as a symbol of wealth, power, and reassurance of social standing (Caldwell, 2013; Environmental Investigation Agency, 2013; Milliken & Shaw, 2012; Smith, 2012; Tanner, 2015). These among others are considered catalysts for the increased demand for rhino horns, posing a serious challenge to rhino conservation in Africa, and threatening to undermine decades of conservation achievement (Milliken & Shaw, 2012).

The increase in demand and recent upsurge in rhino poaching has given rise to a kaleidoscope of debates on best conservation strategies. Though many authors, rhino owners, government officials and environmentalists have suggested different conservation strategies to reduce the number of poaching incidents, there appears to be controversy and confusion on what works best, thus putting rhino conservation at risk.

2.3 Curbing rhino poaching in South Africa

Whether poaching occurs on a particular population can be considered to be a function of reward and risk to a poacher as suggested by Du Toit (2011). Poaching is thus likely to be reduced by either reducing the reward to the poachers, or increasing the risk and difficulty associated with poaching. It is apparent that all strategies advanced to curb rhino poaching revolve around these two factors. Several authors have highlighted different strategies aimed at reducing poaching (Department of Environmental Affairs (DEA), 2013; Duffy et al., 2013; Ferreira et al., 2014; Mukwazvure & Magadza, 2014; Sollund & Maher 2015). These include the legalisation of international trade in rhino horn, demand reduction strategies, dehorning, translocation, improving law enforcement, local community involvement and political will (specifically in tackling corruption). The following sections critically analyse some of these strategies, their past effectiveness and provide practical considerations in the event of implementation.

2.3.1 Legalisation of international trade in rhino horn

The international trade in rhino horn is currently prohibited by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), of which South Africa and another 183 countries are party to (CITES, 2016). Lifting this international ban on the trade in rhino horn and adopting a market approach has been campaigned for by major private and state rhino stakeholders and economists to fight both the illegal trade and reduce rhino poaching (Milliken & Shaw, 2012). Owing to this, the Department of Environmental Affairs set up a Committee of Inquiry in 2015 to investigate the feasibility of international trade in rhino horn (DEA, 2015a).

The rationale for the legalisation of trade in rhino horn is based on the premise that poaching and illegal trade are a consequence of the trade ban imposed by CITES (‘t Sas-Rolfes, 2012; Biggs et al., 2013; Eustace, 2012; Jones, 2015). It is argued that this supply reduction, provoked by the trade ban stimulates the black market and drives rhino horn prices up, providing a powerful incentive for poaching and horn trafficking (Nadal & Aguayo, 2014). Pro-trade lobbyists suggest that a legal supply of rhino horn will reduce the market price of rhino horn, thus making illegal trade economically unviable, and thereby reduce poaching to a significant degree (‘t Sas-Rolfes, 2012; Aguayo, 2014; Biggs et al., 2013; Conrad, 2012; Eustace, 2012). It is also argued that the income generated from the sale of these items can continue to contribute to the expansion of rhino population (Bulte & Damania, 2005; Collins et al, 2012; Fischer, 2004; Milliken & Shaw, 2012; Nadal & Aguayo, 2014). Furthermore, regulated trade could alleviate rural poverty and uplift local communities by providing these communities a chance to own and protect these animals as well as generate an income from them by selling their horns (Maenetja, 2015). Maenetja (2015) explains that communities that have invested in the survival of the species will be less likely to engage in poaching or offer support to poachers in exchange for money.

Anti-trade lobbyists suggest that lessons can be learnt from case studies provided by the two one-off sales in elephant ivory. In 1999 and again in 2008, CITES allowed trade in the form of once-off sales of stockpiled ivory from elephants in an attempt to reduce elephant poaching. The International Fund for Animal Welfare reported that elephant poaching in Zimbabwe, Zambia, the Democratic Republic of Congo, Ghana and other African countries escalated when the decision to allow the sale was allowed (Del Baglivo, 2003; Hitch, 1998). Kenya also saw a rise in poaching levels where poachers reportedly killed 29 elephants in 1999, five times the average annual total during the CITES ivory ban (Del Baglivo, 2003).

Further to be considered are the arguments of authors Bulte & Damania (2005) and Fischer (2004) who question whether the legal trade in rhino horn would provide the benefits and reduction in poaching as suggested by advocates of rhino horn trade legalisation. Fischer (2004) suggests that the end-market for rhino horn does not act as a single market and that both legal and illegal markets can exist simultaneously, and that illegal markets will still attract a premium price for rhino horn, and poaching will still exist. This possibility is reinforced by a recent study in the willingness of Chinese consumers to pay for bear bile from "wild" as opposed to "farmed" sources (Campbell, 2013). Further evidence is also supplied by TRAFFIC (2009) that suggests that consumers actually show a preference for "wild" over captive-bred tiger bone, motivated by the belief that "wild" animals are "unpolluted" and "precious". This suggests that legalising trade won't necessarily just replace the illegal trade but perhaps run simultaneously with the illegal trade. If this could occur, poaching will not necessarily decrease as assumed (Campbell, 2013).

Under the assumptions of the pro-trade argument, illegal suppliers passively accept the new legal market conditions, and simply reduce the supply of illegal quantity while accepting smaller amounts of profit (Campbell, 2013). Bulte and Damania (2005) however argue that illegal traders may not react this way but may in addition to accepting reduced profits, supplement this with increased supply and sales of illegal rhino horn to maintain aggregate levels of profit. In the event where this occurs, the paradox may increase levels of poaching rather than decrease levels of poaching that is anticipated.

Aguayo (2014) and Fischer (2004) further suggest that the current trade ban may in fact have provided a negative stigma around the consumption of rhino horn to a large percentage of the consumer population, and argues that this negative stigma could be reduced under legalised trade. Legalising trade in rhino horn could legitimise such unproven theories about the medical value of horn and may instead increase the demand for rhino horn by bringing in new consumers, an outcome which is not desired by either parties advocating for or against the legal trade in rhino horn (Campbell, 2013).

Another concern surrounding the legalisation of trade has been brought forward by Fischer (2004), who notes that even in a well-regulated market, some degree of laundering is likely to occur. Illegal traffickers laundering illegal horn and selling the poached horn as legal horn will continue to increase poaching while allowing the illegal traffickers to access the market without engaging in dangerous and costly distribution activities (Aguayo, 2014). Fischer (2004) considers laundering of illegal horn to be a serious risk to the legitimacy of the trade, especially in countries such as South Africa where corruption is rife.

Aguayo (2014) further addresses several other risks and uncertainties regarding the legalisation of trade. These include the lack of rigorous data in providing information of market conditions such as market size, potential demand, the sensitivity of demand to price movements, or the prices to which poachers and illegal traders will choose to abandon the market. There is also a risk that there will not be enough rhino horn from legitimatised means to satisfy the demand (especially if it begins to increase) and the remaining demand will be satisfied through poaching of rhinos (Kotze, 2014).

Furthermore, reference to the precautionary principle approach argues that if the environmental consequences of a particular project, proposal or course of action are uncertain, then the project, proposal or course of action should not be undertaken (Newton & Oldfield, 2005). South African environmental legislation has the precautionary principle firmly entrenched within its content, being mentioned in the National Environmental Management Act (No. 107 of 1998) (Cooney, 2004). With the implementation of this principle, legalisation of trade should not be considered until all the risks and uncertainties are better understood.

2.3.2 Demand reduction

The demand for rhino horn has been identified as one of the main driving forces for the escalation in poaching hence efforts to reduce the demand for rhino horn in consumer countries are essential to curb poaching. Demand reduction strategies have mostly concentrated on educating consumers about the plight of the rhino and thus encouraging them to stop consuming rhino horn, and to make use of alternatives or substitutes for rhino horn (Vigne & Martin, 2001; Vigne & Martin, 2013; Vigne et al., 2007).

However, advocates of legalisation in rhino horn trade argue that demand for rhino horn is inelastic due to a historic cultural belief in rhino horn and its perceived cure for ailments, therefore demand reduction strategies are unlikely to succeed in mitigating rhino poaching and horn trafficking (‘t Sas-Rolfes, 2012; Conrad, 2012). Despite this contrary view, lessons can be learnt from the case of shark fin soup in China. In a report by WildAid (2014), it is estimated that the sale of shark fin dropped by 82% in Guangzhou city, China between 2012 and 2014. WildAid attributes this decline to the various awareness campaigns aimed at reducing demand (WildAid, 2014). There have also been successful strategies to reduce demand for rhino horn in various countries. For example, in the 1970s and 1980s Yemen’s demand for rhino horn as dagger handles caused near obliteration of the northern white rhino and subsequently the black rhino by the early 1990s (Vigne & Martin, 2013). In 1992, Yemen engaged in demand reduction strategies to reduce the use of rhino horn even resorting to religious methods to discourage the use of rhino horn (Martin et al., 1997). To promote substitutes for rhino horn, the Yemen government removed water buffalo horn import tax followed by public campaigns through banners, posters and media attention sensitizing people on the plight of rhinos (Vigne & Martin, 2013). The result was a decline in rhino horn demand as most craftsmen resorted to carving water buffalo horns for handles by the 1990s (Vigne & Martin, 2013).

Countries such as Taiwan and South Korea were also major consumers of rhino horn during the 1980s and 1990s. However, after persuasion by the United States and threats of sanctions, the enactment of legislation by both countries forbidding the use of rhino horn for pharmaceutical purposes also resulted in the abandonment of rhino horn use by these countries (Ellis, 2013).

These successes emphasise the fact that use of a single demand reduction method may not be enough but that recourse to a combination of strategies in addition to demand reduction through awareness campaigns, including legislation, the use of substitutes, and government commitment can be effective in curtailing illegal trade and can provide a precedent to significantly reduce current rhino horn demand and subsequent use.

2.3.3 Dehorning

Dehorning involves the removal of the majority (70 – 80%) of the front and rear rhino horns while the animals are sedated (Atkinson, 1996). An instrument such as a wood saw or a power saw is used to remove the horn. The remaining stub of the horn is clipped, shaped and filed smooth (Atkinson, 1996). The rationale for dehorning is aimed at reducing the incentive to hunt and kill the animals. If there is no horn to remove, it is believed that poachers will have no reason to target and poach the rhinos.

Dehorning is currently practiced haphazardly in South Africa depending on the different stakeholders' opinions on the matter (Lindsey & Taylor, 2011). Dehorning as a conservation strategy has registered varying results contingent on the approach adopted. For example, in Namibia where dehorning was combined with other conservation strategies such as increased funding, security and law enforcement, not a single dehorned rhino was poached, while in Zimbabwe the white rhino population decreased from 100 rhinos to 5 or 6 after dehorning (Lindsey & Taylor, 2011). The dehorned failure in Zimbabwe was attributed to a constrained budget which resulted in decreased field patrols and rangers within the protected areas, forcing officials to rely solely on the dehorned strategy (Lindsey & Taylor, 2011).

Swaziland endured severe rhino poaching from 1988 to 1992 when 80% of the nation's rhinos were poached (Lindsey & Taylor, 2011). The subsequent adoption of a combination of strategies including dehorning, arming of rangers with automatic weapons and translocation of rhinos to Intensive Protection Zones (IPZs) drastically curbed the poaching to only two rhinos after 1992 (Lindsey & Taylor, 2011).

However, despite the seeming successes related to dehorning, there are a number of considerations that inhibit the successful implementation of this approach when implemented in South Africa. Firstly, under the current legal system, the Threatened or Protected Species (TOPS) regulations (published in Government Gazette No 29657 Notice No R152) state that any restricted activity involving a specimen listed under TOPS may not be undertaken without an issue of a permit. Dehorning constitutes a restricted activity and thus a number of permits are required for a rhino owner to engage in dehorning rhinos (Lindsey & Taylor, 2011). Secondly, this process involves not only time and costs, but also poses a perceived security risk for the horns. Lindsey and Taylor (2011) found that the permitting system for possessing, transporting and storing of rhino horn is considered by private rhino owners as a security risk due to possible leakage of information to thieves on the whereabouts of horns.

A further consideration is that dehorning has been linked to high costs including costs prior to commencement of the dehorning, finding the animals (usually with the use of helicopters), the immobilisation process, and after care of the rhino horn (Lindsey & Taylor, 2011). Estimates of the current cost of dehorning can reach up to eight thousand rand (US$585) per rhino dehorned (Trendler, 2011). It is also important to note that dehorning is not a once-off management strategy but if adopted needs to be repeated every 12-24 months to maintain the benefit of dehorning as a deterrent for potential poachers (Lindsey & Taylor, 2011).

Other dehorning arguments unrelated to financial costs involve the potential mortality risk which has been recorded under anaesthesia (Lindsey & Taylor, 2011), although advances in capture techniques and improved drug combinations are said to minimise rhino mortality risk (Lindsey & Taylor, 2011). Furthermore, ethical concerns add to the apparent complexity of dehorning as rhinos use their horns for a number of behavioural functions including defending territories; defending calves from predators or other rhinos; guiding calves and maternal care; and foraging such as digging for water, breaking branches or removing tree barks (Trendler, 2011). There is therefore concern that horn removal may impact negatively on these rhino horn functions and the behavioural pattern of affected individuals (Berger & Cunningham, 1996; Trendler, 2011)

Probably the most important concern regarding dehorning is what to do with the horns after removal. The argument is that dehorning transfers the risk of horn possession from the rhino to the horn owner as stockpiled horns are a target for theft, forcing many rhino owners to further invest in security for their stockpiled rhino horns (Lindsey & Taylor, 2011). Many rhino owners are currently storing their stockpiles in the hope of future legalisation which would enable them to sell for profit, which they argue could be used to cover their spiralling security costs (Ellis, 2014). Ellis (2014) also warns that these stockpiles of rhino horns serve as evidence of rhino mortalities that may be used in rhino-crime prosecutions.

The destruction of rhino horns and rhino horn stockpiles has been suggested as an alternative to the storage of rhino horns. Scanlon (2014) points to various countries such as Belgium, Chad, Gabon, France, and the USA who have destroyed confiscated stockpiles of ivory and rhino horn over the last few years. This option is supported by a number of arguments including thoughts that stockpiles present a large target for thieves and substantial sums of money and staff are needed to ensure adequate security for the horns. Further to this, in countries where there are concerns about corruption, it may be better to destroy horns, thus eliminating the risk of leakage onto the black market (Scanlon, 2014). Advocates of rhino horn destruction also maintain that the burning and crushing of horns gain publicity and makes a political statement that rhino horn is worth nothing and also sends a strong signal to the criminal networks that the smuggling of rhino horn will not be tolerated (International Rhino Foundation, 2016).

The argument presented as in the case of demand reduction already discussed in the previous section, the implementation of a single strategy like dehorning or the destruction of confiscated rhino horn would fall short of drastically curbing its illegal trade. Rather, as illustrated in the case Namibia and Swaziland, there is a likelihood of success when such a strategy is coupled with other management strategies and measures (Lindsey & Taylor, 2011).

2.3.4 Translocation

Translocation is the intentional movement of individual animals/plants from one area to another. This method has been used historically in various countries for a variety of different reasons (Griffith et al., 1989) such as improving the chances of survival, establishing new populations, increasing the range of the species, reducing numbers of a population that are overstocked, keeping established populations productive, or introducing and increasing genetic diversity within the population.

Translocation has played a very important role in the history of rhino conservation in South Africa, being instrumental in one of the largest conservation success stories where the southern white rhino was saved from near extinction (Emslie et al., 2009). Translocation is also at the forefront of the Black Rhino Range Expansion Project, established in 2003 by World Wildlife Find (WWF), Ezemvelo KZN Wildlife and Eastern Cape Parks and Tourism (WWF, 2014). The project establishes new populations by moving groups of black rhino from existing Ezemvelo reserves, such as Hluhluwe-iMfolozi Park, to a large, secure private or communally owned property (WWF, 2014). Since the project began in 2003, 10 new populations have been relocated to new sites with more than 60 calves on project sites (WWF, 2015).

During August of 2014, plans were made to translocate up to 500 rhinos from areas within Kruger National Park (KNP) where they are under threat to more secure and safer locations (DEA, 2015b). In addition, approximately 100 rhinos were translocated to neighboring countries in 2014, all aimed at creating rhino strongholds where rhinos can be cost-effectively protected while applying conservation husbandry to maximize populations (DEA, 2015b). KNP has been the hardest hit by poaching, with the majority of incidents in South Africa occurring within its fences. Translocating rhinos out of densely populated areas into more secure undisclosed locations increases the difficulty and effort required to find the rhino to poach (DEA, 2015b).

Examples of African countries where translocation yielded good results include Zimbabwe where in early 2008, poaching reached critical levels prompting the translocation of more than 50 black rhinos out of particularly vulnerable to more secure areas. These translocations, combined with improved security, have resulted in a decline in poaching (International Rhino Foundation, 2014).

However, translocation is not free from hurdles and practical considerations. These among others include the number of rhinos to be translocated, the identification of suitable areas for relocation, issues related to security, politics, veterinary, fencing, future funding, different ownership/management models, size of the recipient reserve and habitat quality and suitability (Emslie et al. 2009).

The implementation of translocation as a rhino conservation strategy may not be successful on its own except in combination with other measures namely increased law enforcement, dehorning, proper care and wellbeing of the animals, their habitation in fenced enclosures away from international borders and away from areas free from civil war or unrest (Emslie et al. 2009).

2.3.5 Law enforcement

Any illegal activity such as poaching is non-compliance to a rule, law or regulation, therefore improving compliance is essential to reducing poaching. One way to improve compliance is through enforcement of the law (Arias, 2015). Much focus has been placed on the improvement of law enforcement in combating poaching (Bega, 2014; Eustace, 2012; Rauniyar, 2015; Sellar, 2014; Westervelt, 2015). For the purposes of this paper "enforcement" is defined as a system comprising detection, apprehension, prosecution and the conviction of lawbreakers (Akella & Cannon, 2004).

With regards to rhino poaching, detection needs to be achieved before the rhino is poached and hence the need for law enforcement within rhino protected areas. The deployment of law enforcement including rangers on patrol, anti-poaching units, spotter planes, and sniffer dogs within protected areas are currently avenues in which law enforcement is used to protect rhinos (Emslie & Brooks, 1999; Welz, 2013). The key principle behind this is that the concentration of law enforcement will maximise the risk to potential poachers as poachers will have a higher degree of detection and apprehension (Du Toit, 2006). In the cases mentioned earlier in this paper, where reduction in poaching was realised in countries such as Namibia and Swaziland, increased and effective law enforcement was a crucial component in these strategies' success. For example, investment in increased patrolling and law enforcement has been cited as an important determinant in poaching reduction and the increase in buffalo, elephant and black rhino populations in the Serengeti National Park, Tanzania (Hilborn et al. 2006). Similar results have been registered in Ghana, where increased law enforcement and patrols resulted in a 22% reduction of elephant poaching (Martin, 2010).

Poached rhino horn travels along an elaborate trade chain that spans countries, oceans and continents and therefore proper law enforcement at ports of entry and exit in countries is also essential in the detection and apprehension of criminals involved in wildlife crimes (African Wildlife Foundation, 2014; Bega, 2014; Martin, 2010; Sellar, 2014). Law enforcement also needs to involve the successful prosecution and conviction of criminals involved in rhino horn trafficking to such an extent that poachers and wildlife traffickers are deterred from engaging in wildlife crime for fear of prosecution and conviction (Akella & Cannon, 2004). In a recent report by Rademeyer (2016), it is suggested that the 'war' on poaching will be won in the courts and not in the bush.

However, law enforcement as a system and strategy to curb rhino poaching can only be effective where there are no weaknesses and gaps in the system. This is not the case in South Africa where weaknesses in law enforcement include poor interagency cooperation, the lack of capacity, resources and skills, corruption, and conflicting regulations (Akella & Cannon, 2004; Rademeyer, 2016).

Only three pieces of national legislation impose criminal liability for wildlife offences (including poaching of rhino for their horn, and trading in rhino horn). These include the National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA), the Threatened and Protected Species Regulations (Notice 388 of 2013) and the CITES Regulations (GNR.173 of 5 March 2010). The NEMBA states that a person is considered guilty of an offence if that person fails to comply with the provisions of the regulations. If convicted, a person is liable to "imprisonment for a period not exceeding five years; a fine not exceeding five million rand (US$366017), and in the case of a second or subsequent conviction, to a fine not exceeding ten million rand (US$732033) or imprisonment for a period not exceeding ten years". However, penalties under provincial legislation differ to that of national legislation and from province to province causing confusion and weaknesses in the law enforcement system. For example, in Limpopo Province, the Limpopo Environmental Management Act 7 of 2003 Section 117 (1) states that a person found guilty of an offence is liable to a "fine not exceeding two-hundred and fifty thousand rand (US$18300) or to imprisonment for a period not exceeding fifteen years or to both such fine and such imprisonment", while in KwaZulu-Natal, the Nature Conservation Act No. 29 of 1992 Section 12 (1) states that a person guilty of an offence within the provisions of the Act will be liable to a "fine not exceeding one-hundred thousand rand (US$7320) or to imprisonment of a period not exceeding ten years, or to both such fine and such imprisonment". Not only are these sets of legislation inconsistent, presenting prosecutors with a dilemma on which set of legislation to implement their specific case but the fines are inadequate considering that the estimated retail cost of rhino horn per kilogram is eight hundred and twenty thousand rand (US$60000) (Michler, 2011).

Akella and Cannon (2004) and Rademeyer (2016) suggest a chain of actions necessary to increase the effectiveness of enforcement including increasing capacity building and resources in the detection and apprehension of wildlife criminals as well as strengthening legislation and policy to ensure that penalties sufficiently compensate for the environmental damages. Such penalties and/or convictions should be heavy and harsher enough to raise the level of risk associated with poaching and thus deter potential poachers. The aim should be to drain the syndicate of any accumulated earnings from illegal rhino horn sales (Akella & Cannon, 2004). This could be achieved by providing for minimum sentences for persons found guilty – currently all South African legislation only allows for maximum sentences thus leaving sentencing to the discretion of the judge. A judge whose understanding of environmental law is limited may sentence and apply penalties inappropriately, thus undoing good work of the agencies that handled the case earlier in the enforcement chain (Akella & Cannon, 2004). For example, in 2014, a Thai national who had previously been sentenced to 40 years for rhino horn smuggling and fraudulently obtaining 26 rhino hunting permits had his sentence reduced twice, once to 30 years and again to 13 years after appeal (South Africa Press Association (SAPA), 2014), probably because there is no minimum sentence. He was also fined one million rand (SAPA, 2014; Smillie, 2013). Imposing a fine of one million rand is not a sufficient deterrent considering the price of eight hundred and twenty thousand rand (US$60000) per kilogram of rhino horn (Michler, 2011; Smillie, 2013).

Poor interagency cooperation has been addressed extensively by Rademeyer (2016) who suggests that until fairly recently, the DEA and conservation agencies have been driving all law enforcement responses to curb rhino poaching in South Africa. However, these agencies have neither the mandate nor the political resources and power to address transnational organised crime (Rademeyer, 2016). As such, the responsibility for tackling this transnational highly organised criminal syndicates involved in rhino poaching is being shifted towards security ministries, police departments and justice departments (Rademeyer, 2016). However, Rademeyer (2016) explains that although this shift is necessary, there are still significant lack of collaboration and information sharing between police stations, police units, national parks, government departments, security agencies and the defence force among others. This is mainly attributed to the lack of trust commonly referred to as the 'silo effect' whereby agencies work within their jurisdiction and rarely communicate with each other (Rademeyer, 2016). This lack of trust may stem from the high levels of corruption within the variety of agencies involved (Rademeyer, 2016).

Growing numbers of police officials, game rangers, park staff, judges and custom officials are involved in corrupt activities of rhino horn trafficking (Fenio, 2014; Rademeyer, 2016). Over the past few years, many arrests related to rhino poaching have been made including corrupt police officials and park rangers (DEA, 2014; Gosling, 2015; Hosken, 2016; Magwedze, 2016; Pretorius, 2016). The courts are also implicated in rhino poaching corruption. For example, a magistrate in KwaZulu-Natal who presided over multiple rhino poaching cases in which poachers pleaded guilty were said to have received extremely small fines and no jail time (Joseph, 2016). A specific example is that of known rhino poaching kingpin who was arrested in December 2014 and after appearing in court was only given a ten-thousand-rand (US$732) bail and all of his vehicles previously seized by the South Africa Police Service were released by the same magistrate (Joseph, 2016).

Disrupting the criminal syndicates of rhino horn trafficking requires a radical change to the current fragmented law enforcement strategies (Rademeyer, 2016). It requires efforts from law enforcement and intelligence structures at local, national, regional and international level, all collaborating together. Concentrated efforts especially in the prosecution and conviction of high-level figures in the rhino poaching chain and clamping down on corruption at all levels will have the greatest impact in reducing poaching (Rademeyer, 2016).

2.3.6 Local community involvement

Involving the local community that surround parks and protected areas is another crucial element that cannot be overlooked when attempting to curb rhino poaching (Lotter & Clark, 2014). It is extremely difficult for poachers to be successful without local community participation (Fischer et al., 2005). Local community participation in poaching is the manifestation of problems caused by the need for cash, lack of viable alternatives, lack of understanding of the importance of conservation, and the lack of good relationships between community members and protected area authorities (Lotter & Clark, 2014).

Fenio (2014) has elaborated on a number of issues that impede the successful participation of communities in rhino conservation and anti-poaching endeavours. The main issues include a lack of a good relationship with the park's management, economic incentives provided by poachers, corruption and fear of retribution from informing on poachers.

The recognition and treatment of these issues is imperative in successfully curbing rhino poaching. Benefit sharing and community integration in conservation activities will aid to discourage their direct or indirect participation (harbouring and protecting poachers) in poaching (Fischer et al., 2005). Local community involvement can successfully aid in the building of conservation and enforcement capacity. Community-based conservation is not a new phenomenon (Ashley & Roe, 1998; Berkes, 1989; Berkes, 2004; Kiss, 2004; Martin, 1998; Martin & Martin, 2010). The Ruvuma Elephant Project (REP) in Tanzania clearly demonstrates the benefits of engaging with local communities in an effort to improve and increase their enforcement capacity and thus reduce poaching (Lotter & Clark, 2014). The REP lies between the Selous Game Reserve and the Niassa National Park and aims to improve the status of elephant conservation (Lotter & Clark, 2014). The primary objectives of REP revolve around reducing elephant poaching through local community engagement in a variety of avenues. These include implementing field patrols that consist of local villagers and wildlife officials, providing incentives and rewards for good performance, implementation of a programme that mitigates human-elephant conflict by protecting local communities' crops against elephants, and supporting local income generating activities (Lotter & Clark, 2014). The REP has involved local communities extensively in their objectives and through this collaboration, elephant poaching levels decreased substantially in 2013 compared with poaching levels in 2011 and 2012 (Lotter & Clark, 2014). In the case of the REP, the local community worked alongside the wildlife officials and through this holistic approach, a reduction in large-scale poaching was achieved (Lotter & Clark, 2014).

2.4 Conceptual framework of anti-poaching strategies

Due to the escalating increases in rhino poaching since 2008, this study sought to analyse anti-poaching strategies, their strengths and weaknesses. Analysis of each strategy reveal that implementation of a single strategy alone would yield minimal results as opposed to an integrated, holistic approach, combining different strategies concurrently. These strategies include demand reduction at the end-user, increased law enforcement (within protected areas, within the justice system and along the supply chain), dehorning, translocations, local community involvement and political will. This suggested holistic approach can be better presented and visualised in a conceptual framework (Figure 2.1) of anti-poaching strategies. Though the strategies therein work well in conjunction with each other, they can be grouped into four anti-poaching approaches namely the market approach (demand reduction), the environmental approach (translocation and dehorning), the social approach (community involvement) and the legal approach (law enforcement).

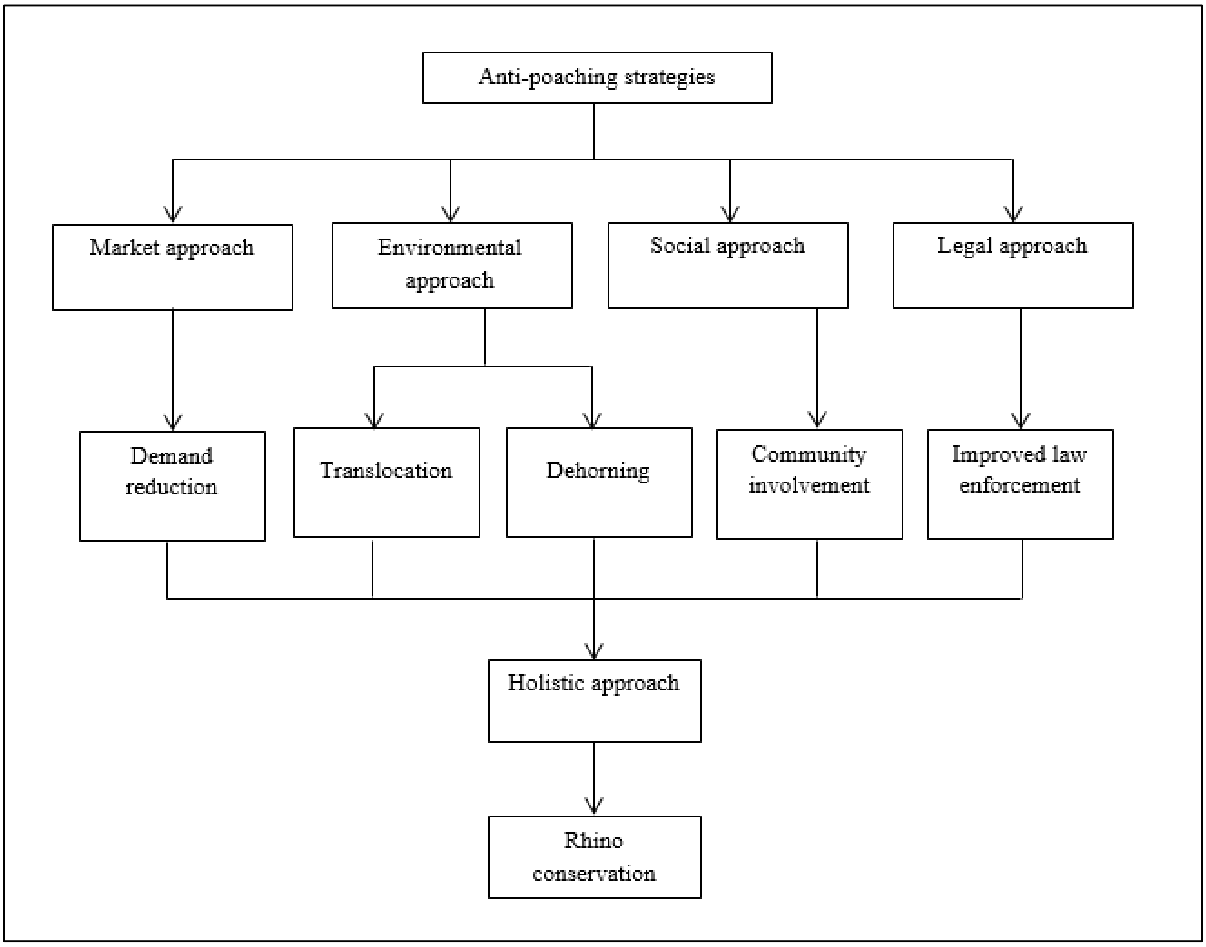

Figure 2.1: Conceptual framework of anti-poaching strategies

2.5 Conclusion

The future survival of rhino is at the forefront of many conservation discussions. Since the rapid escalation of rhino poaching from 2008 in South Africa, several management strategies have been suggested to curb rhino poaching in the country. Reducing poaching is a combination of decreasing the reward to the poacher/trafficker while increasing the risk or difficulty of engaging in wildlife crime. Since poaching involves a combination of aspects, it is apparent that no one strategy, implemented in isolation will address the rhino issue on its own. A combination of strategies that address all aspects of poaching need to work concurrently to decrease poaching levels.

For South Africa to win the war against rhino poaching, a clear vision of what strategies complement each other is needed. This paper has attempted to address some management strategies that have been suggested, analysing their shortcomings and effectiveness in reducing poaching. A conceptual framework of different strategies has been suggested showing their best possible combination for curbing the rhino poaching in South Africa and in other countries affected by rhino poaching. In addition to these, there is need for collaboration, strong commitment and concerted buy-in from all tiers and sectors of the society if the rhino poaching crisis is to be brought under control, ensuring the survival of the rhino population in South Africa.

Although legalisation of rhino horn trade has been advocated by various stakeholders as a sustainable strategy to reduce rhino poaching and may provide much needed income and funds to reduce rhino poaching, there are still many uncertainties due to the lack of research and understanding of the dynamics of the trade in rhino horn, including markets as well as the costs of setting up and maintaining a regulated trade. Since the outcome of rhino horn trade legalisation is unclear and the risks are unknown, implementation of a legal trade in rhino horn should not be considered at this present time.

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CHAPTER THREE

ANALYSING THE SPATIAL AND TEMPORAL PATTERNS OF RHINO POACHING IN THE HLUHLUWE-IMFOLOZI PARK, SOUTH AFRICA USING GIS

Moneron SL and Ngetar SN. An investigation into the spatial and temporal patterns of rhino poaching in the Hluhluwe-iMfolozi Park, South Africa using GIS (Paper submitted to the Geocarto International Journal)

3.1 Abstract

The conservation of rhino is suffering significant setbacks as incidents of rhino poaching for their horn have increased substantially since 2008, particularly in South Africa. With increasing poaching incidents in the Hluhluwe-iMfolozi Park (HiP), law enforcement efforts in the form of deployment of anti-poaching units, focused on high risk areas would provide for a more efficient and effective use of resources in reducing poaching incidences. This study sought to investigate the spatial and temporal patterns of rhino poaching in the HiP between 1990 and 2013 and examine the relationships between observed patterns of poaching and biophysical and human variables using Geographic Information Systems (GIS). The study made use of rhino poaching data and various GIS data layers representing biophysical and human variables to analyse the patterns of rhino poaching. The observed patterns were then related to the biophysical and human variables using correlation analysis. The results reveal poaching hot spots, and spatial and temporal variation in poaching incidences. Biophysical and human variables were also found to influence poaching densities differently depending on where they occurred spatially or temporally. The successful use of GIS in this analysis validates its potential as a geospatial tool for understanding the spatial and temporal distribution patterns of rhino poaching within the HiP. Understanding these patterns is crucial for future anti-poaching planning and mitigation of poaching activities with protected areas.

Keywords: rhino poaching, GIS, spatial and temporal patterns, biophysical and human factors, correlation analysis

3.2 Introduction

The illegal hunting and global trade in wildlife and wildlife products is a multi-billion-dollar industry estimated to be worth US$50-US$150 billion per year (United Nations Environment Programme (UNEP), 2014). This transnational, highly organised crime continues to threaten the survival of many endangered species globally (UNEP, 2014). The rhinoceros (rhino) is a well-known example of this trade, despite the fact that all five of its species appear on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2014). The demand for rhino horn for use in East Asian medicine as well as for ornamental purposes in countries such as Vietnam, has resulted in declines of rhino populations globally culminating in the Western Black rhino in Africa (*Diceros bicornis longipes*) officially being declared extinct in 2011 (Emslie, 2011).

In a recent report compiled by the IUCN Species Survival Commission's African Rhino Specialist Group, the number of African rhinos killed by poachers has increased for the sixth year in a row with at least 1,338 rhinos killed by poachers across Africa in 2015 (IUCN, 2016). This is the highest level since the current crisis emerged in 2008, resulting in at least 5 940 African rhinos being killed (IUCN, 2016). Majority (85%) of these poaching incidences occurred within South Africa (Emslie et al., 2012). South Africa plays a leading role in the conservation of the African rhino, conserving a record number of approximately 20 711 rhinos (83% of the total African rhino population and 73% of wild rhinos globally) ('t Sas-Rolfes, 2012; Emslie et al., 2012). If poaching continues to increase as in the past few years, the rhino population within South Africa may begin to decline as early as 2016 (Emslie, 2012).

Majority of the studies on rhinos have mainly focused on aspects of population size and distribution, movement, home range estimation and habitat preferences (Buk & Knight, 2010; Emslie, 1999; Lent & Fike, 2003; Lush et al., 2015; Perrin & Brereton-Stiles, 1999; Rachlow et al., 1999). In recent years, due to increasing rates of poaching, numerous studies have also been published on the illegal trade of rhino horn, the demands, causes and potential solutions to this illegal trade (Martin & Martin, 2010; Milliken, 2014; Milliken & Shaw, 2012; Lindsey & Taylor, 2011; Lotter & Clark, 2014).

Not many studies however have sought to understand the spatial and temporal trends of rhino poaching within protected areas (Eloff, 2012; Lemieux, 2014; Lockwood, 2010; Walpole, 2000). Obtaining this information is helpful in predicting poaching likelihood and is central to planning, monitoring and mitigation of poaching (Maingi et al., 2012; Sibanda et al., 2015). Furthermore, the findings from Lockwood's (2010) quantitative analysis "highlighted the need for additional research within State run parks to obtain a clearer understanding of the poaching patterns" (p. 47).

The Hluhluwe-iMfolozi Park (HiP) is one such state run park based in KwaZulu-Natal, South Africa. The HiP is famous for its rhino conservation and has the highest density of wild white rhino globally (Carnie, 2016). Although majority of poaching incidents in South Africa have been occurring in Kruger National Park, poachers are beginning to shift their focus to KwaZulu-Natal and in particular to the HiP in recent months (Carnie, 2016; Pieterse, 2016). Anti-poaching patrols would be most effective and efficient if patterns of poaching were understood. In this regard, this study attempted to understand the spatial and temporal patterns of rhino poaching based on the recorded poaching incidents in the HiP, South Africa using Geographic Information Systems (GIS) and other statistical analyses.

Available literature provides important information about which biophysical and human factors may influence patterns of rhino poaching based on rhino distribution and the preferences of poachers (Hebbelmann, 2013; Kyale, 2006; Lush et al., 2015; Odendaal, 2011; Owen-Smith, 1988; Perrin & Brereton-Stiles, 1999). As white rhinos are grazers and feed mainly on grasslands (Perrin & Brereton-Stiles, 1999) and black rhinos are browsers and prefer to spend their time feeding in woodlands and bushlands where they feed on small shoots, leaves and twigs from woody plants (Skinner & Chimimba, 2005), land cover plays an important role in rhino distribution within the HiP. Hebbelmann (2013), Owen-Smith (1988) and Perrin & Brereton-Stiles (1999) studied white rhinos' diet and found that rhino distribution varies between the wet and the dry season within the HiP due to food availability. Owen-Smith (1988) and Perrin and Brereton-Stiles (1999) noted that because of decreasing food availability, rhinos during the dry season moved from the gentle terrain and lowlands up onto hill slopes to graze on the remaining reserves of grasses. Odendaal (2011) also noted that slope and elevation played a role in habitat selection by black rhinos in the Zululand Rhino Reserve, South Africa. Odendaal (2011) also emphasized that rhinos typically avoided areas of human disturbance such as lodges, camps and roads. This is reiterated by findings by Lush et al. (2015) who also noted that human disturbance played a role in habitat selection by rhinos in Ol Pejeta Conservancy in Kenya. Further to this, Kyale (2006) and Leader-Williams et al. (1990) suggest that poachers also tend to target remote areas away from human disturbance such as roads and camps. Targeting remote areas decreases the risks of being caught by rangers (Kyale, 2006).

From the literature reviewed, it is clear that a variety of biophysical and human factors influence rhino distribution and may by extension influence rhino poaching. As such, this study specifically aims to determine whether rhino poaching varied seasonally; whether poaching exhibited clusters as well as to investigate and understand what biophysical and human factors are associated with rhino poaching incidents and the relationship between them. Such information may be useful in guiding the deployment of policing resources throughout the park.

3.3 Methods and materials

3.3.1 Study site

The Hluhluwe-iMfolozi Park falls within the north-eastern region of the KwaZulu-Natal province of South Africa. The park is a state-run protected area approximately 94 984 hectares (ha), completely fenced and divided into three separate sections, the Hluhluwe Game Reserve, the iMfolozi Game Reserve and the Corridor Reserve (Figure 3.1). The HiP falls within the southern African savanna biome, with habitat ranging from open fire-maintained grasslands, to thicket and closed woodlands as well as grazing lawns maintained by grazing herbivores (Ezemvelo KZN Wildlife, 2011). Common grazing herbivores in the park include white rhinoceros (*Ceratotherium simum*), buffalo (*Syncerus caffer*), blue wildebeest (*Connochaetes taurinus*), plains zebra (*Equus quagga*), and impala (*Aepyceros melampus*).

The HiP has a coastally modified climate with annual rainfall being strongly seasonal with most rain falling between October and March. Within the park, mean annual rainfall ranges from 985 mm in the highly elevated northern regions to 650 mm in the low-lying western areas (Ezemvelo KZN Wildlife, 2011). The HiP is divided into three main perennial water courses, the White Umfolozi River, the Black Umfolozi River and the Hluhluwe River, with most of the smaller rivers and tributaries in the park being non-perennial. Other water bodies are represented by numerous seasonal and permanent pans distributed throughout the park (Ezemvelo KZN Wildlife, 2011).

The major access routes to the HiP are through three entrance gates, the Nyalazi Gate (accessed from the R618 public provincial road) in the east situated in the Corridor Reserve, the Memorial Gate in the north-east situated in the Hluhluwe Game Reserve and the Cengeni Gate situated in the south-west section of the iMfolozi Game Reserve (Ezemvelo KZN Wildlife, 2011). Within the HiP, there is a complex road network consisting of primary and secondary roads and management tracks. The primary and secondary roads, approximately 229 km in length are accessible to the visiting public, with only the road from Memorial Gate to Mpila via Hilltop is tarred; while management tracks are used for internal management (Ezemvelo KZN Wildlife, 2011).

A portion of the iMfolozi Game Reserve is declared a Wilderness Area in which all forms of permanent structures such as roads and buildings are prohibited, and only management activities that can be carried out on foot, canoe or horseback are allowed (Cryer, 2009; Ezemvelo KZN Wildlife, 2011). This iMfolozi Wilderness Area was the first to be designated as such in Africa and has increased in size from 12 150 ha to 32 000 ha between 1959 and 2002 (Cryer, 2009).

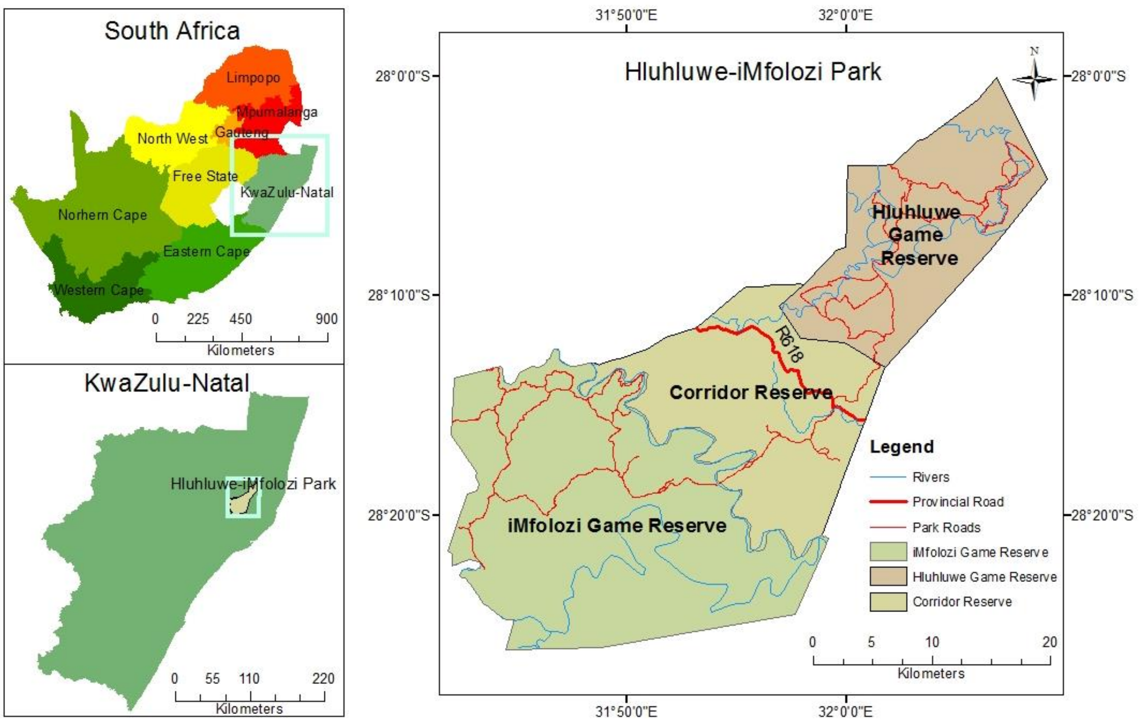

Figure 3.1: The Hluhluwe-iMfolozi Park within KwaZulu-Natal Province, South Africa.

3.3.2 Data layers

Data for this study were obtained from various sources (Table 3.1). This table excludes secondary data derived from those listed. The 30-m DEM listed in the table was obtained from Ezemvelo KZN Wildlife and used to determine slopes in the study area. Other raster and vector datasets obtained from Ezemvelo KZN Wildlife included the land cover map, location of places and their names, the boundaries of the HiP and rhino-related criminal data. The rhino-related criminal data was provided in excel spreadsheet and covered the period from 1 January 1990 to 31 December 2013. Roads, rivers and dams were obtained as shapefiles from the KwaZulu-Natal Department of Transport and the Department of Water and Sanitation respectively.

Table 3.1: Sources of data used in the current study

Data	Format	Source
30 metre Digital elevation model	DEM	Ezemvelo KZN Wildlife
2011 Land cover map of the HiP	Raster	Ezemvelo KZN Wildlife
Major & secondary roads	Shapefile	KwaZulu-Natal Department of Transport
Rivers & dams	Shapefile	Department of Water and Sanitation
Rhino-related criminal data	Excel Spreadsheet	Ezemvelo KZN Wildlife
HiP place names	Shapefile	Ezemvelo KZN Wildlife
HiP boundary	Shapefile	Ezemvelo KZN Wildlife

3.3.3 Data analyses

The rhino-related criminal data obtained included the nature of the criminal activity, name of the place/location of the incident, the year, month and in some cases the exact date in which the incident occurred, as well as the month in which the incident and case was registered (if applicable) with the South African Police Service. Of the total 361 incidents listed, 102 poaching incidents fell within the boundaries of the HiP. Of the 102 poaching incidents, 22 incidents lacked sufficient spatial and temporal data and were excluded from the analyses.

Rhino poaching incidences were categorised into seasons based on rainfall distribution in the study area so to determine if poaching differed between the wet and dry seasons. The months from October to March were categorised as the wet season and April to September were categorised as the dry season as per Reid et al. (2007). Three classes of point shapefiles namely total incidents year-round; dry season incidents; and wet season incidents together with their attributes were created in ESRI's ArcGIS 10.3 (ESRI, 2014). Due to the sensitivity of the data, exact locations of these poaching incidents will not be displayed in this study. These point shapefiles were used as input data in ArcGIS to perform pattern analysis using the Average Nearest Neighbour index aimed at determining the randomness or clustering of incidents throughout the park. The Average Nearest Neighbour tool measures the distance between each feature's centroid and its nearest neighbour's centroid location, and then averages all these nearest neighbour distances (ESRI, 2014). If the average distance is less than the average for a hypothetical random distribution, the distribution of the features is considered clustered (ESRI, 2014). The Nearest Neighbour Index is expressed as the ratio of the Observed Mean Distance to the Expected Mean Distance, and if the index is less than 1, the pattern exhibits clustering (ESRI, 2014).

To understand the spatial distribution of poaching incidences, kernel density analysis was performed on each class of point shapefile created (year-round incidents, wet season incidents and dry season incidents). Kernel density analysis calculates a magnitude-per-unit area from the point feature using a kernel function in order to create an interpolated surface showing the density of occurrence (ESRI, 2014). Each raster cell is assigned a density value and the entire surface is visualised using a gradient (Dempsey, 2014). The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance (bandwidth) from the point (ESRI, 2014). The selection of the bandwidth thus exhibits a strong influence on the resulting surface. In this study a bandwidth of 8 521m was chosen as it is the maximum distance between a point and it's furthest neighbour and was calculated using ArcGIS 10.3's Calculate Distance Band from Neighbour Count tool (ESRI, 2014).

To test the statistical significance of the spatial clusters, Getis-Ord Gi* hot spot analysis tool was performed on the point shapefiles for year-round, wet season and dry season poaching. Getis-Ord Gi* hot spot analysis uses statistical analyses (Getis-Ord Gi* statistic) on both the location and weighted attribute in order to define areas of high occurrence versus areas of low occurrence (hot spots and cold spots) (ESRI, 2014). For this study, the density value extracted from the kernel density analysis was inserted and used as the weighted analysis field. The designation of a point as being a hot spot is therefore expressed in terms of statistical confidence (Dempsey, 2014). To avoid displaying the results of the hot spot analysis as point locations (due to sensitivity of data as mentioned above), the results of the hot spot analysis were interpolated to create a continuous surface from the point values. Kriging is an advanced geostatistical interpolation procedure that generates an estimated surface from a scattered set of points with z-values and was used to interpolate the results of the hot spot analysis (ESRI, 2014).

To determine the spatial patterns of the poaching incidences in relation to biophysical and human factors, distance and density surfaces were generated for park roads, rivers, waterholes, human influences (this includes both public and private lodges, management areas, park offices, park gates and designated public tourist areas within the park), the park's boundary, neighbouring communities and the provincial road that runs through the Corridor Reserve using ArcGIS's Spatial Analyst from available datasets described in Table 3.1. Slope (steepness) was generated using the DEM.

The corresponding distance and density surfaces occurring at each poaching location were extracted using ArcGIS's Spatial Analyst into the three classes of point shapefiles created for year-round, wet season and dry season poaching. To understand the relationships between rhino poaching density and the biophysical and human variables, the corresponding poaching density value and the distance and density surfaces value generated at each poaching location were assessed using the Spearman Rank correlation analysis. The data extracted from the poaching points showed high spatial autocorrelation and therefore regression analysis could not be performed (Maingi et al., 2012). Spearman Rank correlation was chosen as the datasets were not normally distributed (Dytham, 2003).

Finally, land cover data were categorical rather than quantitative and therefore was assessed differently. The land cover types were extracted at each poaching location. The frequency with which poaching occurred within that land cover type was tabulated for each poaching category and the percentage land covers compared.

3.4 Results

A year by year examination of the rhino poaching data from 1990 to 2013 reveals relatively low poaching levels between 1990 and 2007 (≤5), increasing from 2008 to 2013. Between 2008 and 2013, rhino poaching incidents within the park increased at an average rate of 48%, with the highest number of incidents (20) occurring in 2012 (Figure 3.2). Poaching incidences by month revealed that the highest levels occurred between August and December which corresponds with the late dry season and early wet season (Figure 3.3). Approximately 48.8% (39) of the 80 poaching incidences occurred within the dry season and 41 (51.2%) in the wet season. Analysis of poaching by rhino type reveal that 72 (90%) of 80 incidences were white rhinos while the remaining 8 incidences were black rhinos.

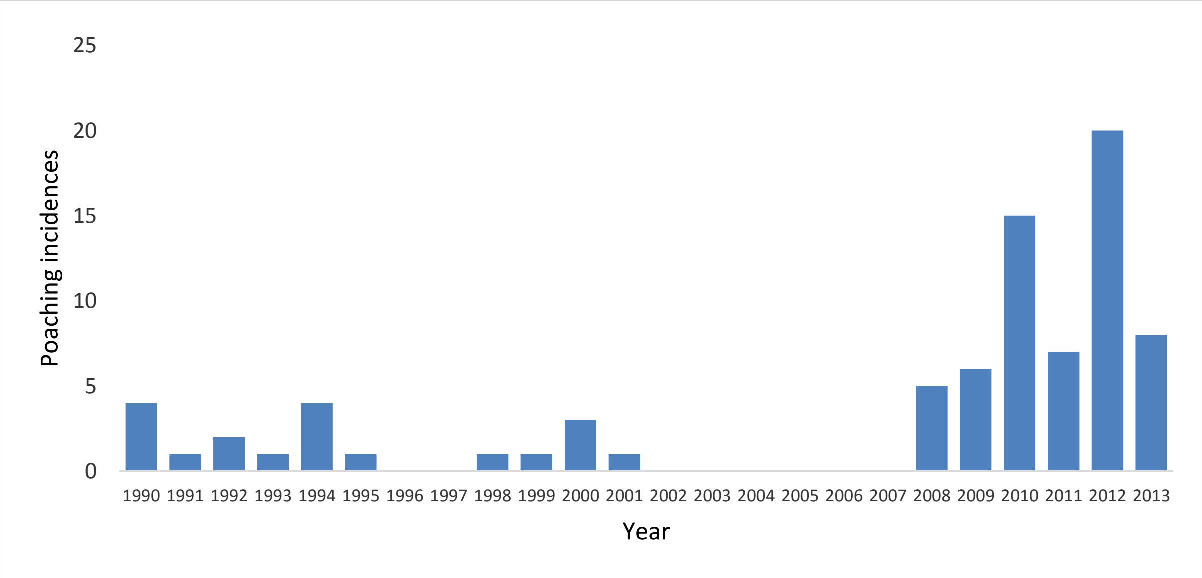

Figure 3.2: Annual rhino poaching incidences (n =80) in the Hluhluwe-iMfolozi Park from 1990–2013.

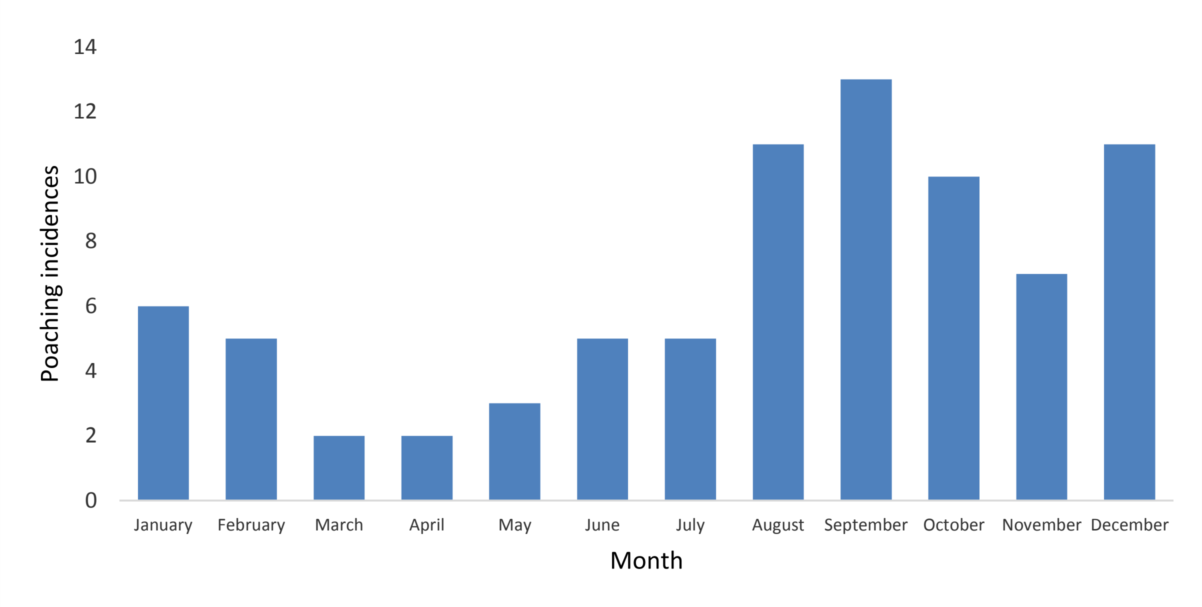

Figure 3.3: Monthly distribution of rhino poaching incidences (n=80) in the Hluhluwe-iMfolozi Park from 1990-2013.

Pattern analysis using the average nearest neighbour analysis revealed that rhino poaching incidences within the HiP were not randomly distributed (Nearest Neighbour Index < 1) but exhibited significant clusters (p-value <0.5) (Table 3.2). This occurred for year-round poaching incidences as well as for dry season and wet season poaching.

Table 3.2: Results from Average Nearest Neighbour analysis

	Nearest Neighbour Index	z-score	p-value
Year round poaching incidences	0.393778	-10.373075	<0.000001
Wet season poaching incidences	0.663234	-4.125262	0.000037
Dry season poaching incidences	0.598085	-4.801726	0.000002

In an attempt to determine where these clusters occurred, kernel density analysis was used and revealed two concentrations or clusters of poaching (Figure 3.4). The first poaching concentration occurs in the south-western tip of the park within the iMfolozi Game Reserve. The second poaching concentration occurs within the Corridor Reserve concentrated along the provincial public road that runs through the park. When poaching clusters were analysed separately for the wet and dry seasons, they remained in similar locations but their intensities differed. In the wet season, the highest intensity of poaching occurred near the south-western tip of the park. There were smaller less intense clusters in the Corridor Reserve. In the dry season, the highest intensity poaching also occurred in the same area as those in the wet season; however, the smaller less intense clusters in the Corridor Reserve that occurred in the wet season become significantly more intense in the dry season.

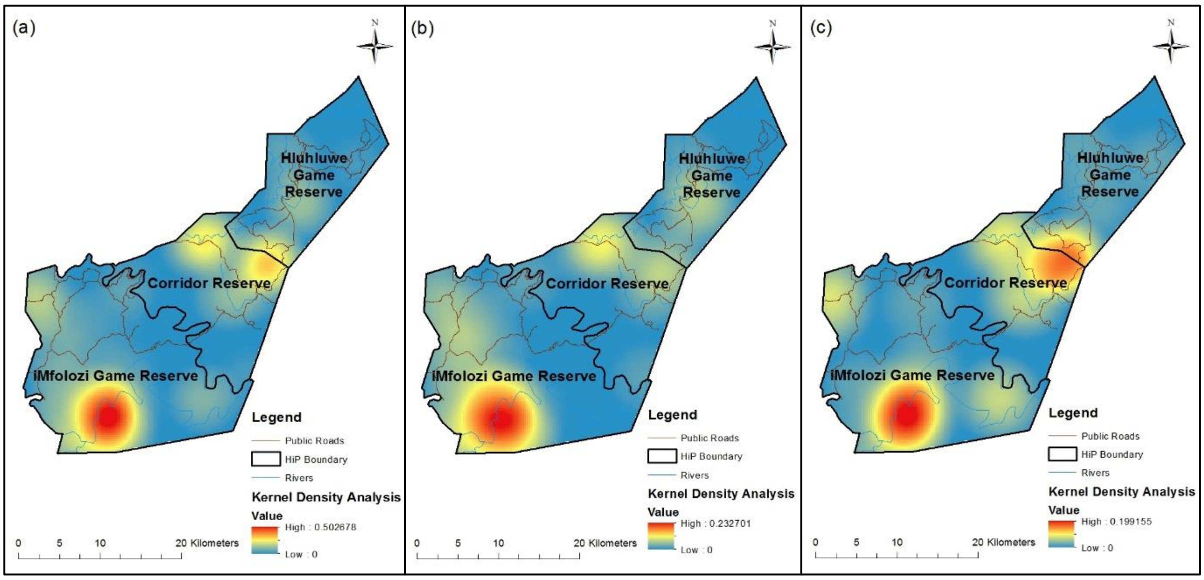

Figure 3.4: Rhino poaching concentrations for the period 1990 – 2013 based on kernel density analysis for (a) year-round poaching, (b) wet season poaching and (c) dry season poaching.

The interpolation from the Getis-Ord Gi* hot spot analysis performed on year-round, wet season and dry season poaching incidents displayed hot spots in similar locations to those poaching concentrations found by the kernel density analysis (Figure 3.5). Significant poaching hot spots were found in the south-western tip of the iMfolozi Game Reserve for year-round poaching, wet season poaching and dry season poaching (Figure 3.5). Unlike the kernel density analyses that identified distinct poaching concentrations within the Corridor Reserve all year round (Figure 3.4a) and in the dry season (Figure 3.4c), the hot spot analyses display a rather gradual increase of the hot spot extending from the iMfolozi Game Reserve into the Corridor Reserve during these periods. This becomes particularly pronounced seasonally, as the hot spots are more concentrated in the wet season in the iMfolozi Game Reserve, and expand into the Corridor Reserve as the dry season progresses.

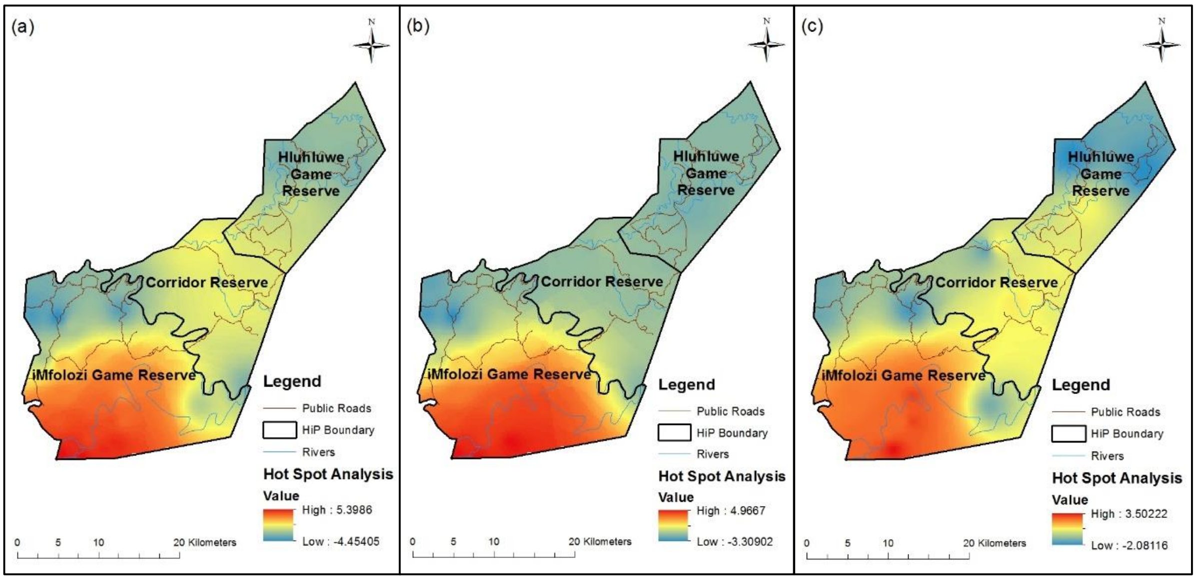

Figure 3.5: Rhino poaching hotspots from 1990 – 2013 based on Getis-Ord Gi* hot spot analysis for (a) year-round poaching, (b) wet season poaching and (c) dry season poaching.

The identification of poaching hotspots with significant clustering in different areas of the park (iMfolozi Game Reserve and Corridor Reserve), presented an opportunity for exploring the correlation between the various biophysical and human factors and the density of rhino poaching for both iMfolozi Game Reserve and Corridor Reserve separately in an attempt to understand what explains the patterns of poaching in these portions of the park. Of all the biophysical and human factors explored, the density of roads exhibited the strongest negative correlation with the density of poached rhinos in the iMfolozi Game Reserve (Table 3.3). This negative relationship was exhibited for all three periods of poaching (year-round, wet season and dry season). All poaching densities were also negatively correlated with distance from human influences; slope, distance from rivers and distance from waterholes with the exception of dry season poaching showing no significant correlation with either distance from rivers or distance from waterholes. Seasonally, elevation negatively correlated with the wet season poaching but positively correlated with dry season poaching. Factors that positively correlated with all three poaching densities in the iMfolozi Game Reserve include distance from roads, distance from provincial road and density of waterholes. Density of rivers also positively correlated with poaching densities except in the dry season when the correlation is negative. Distance from the HiP boundary was found to be only significantly correlated with the wet season poaching while distance from neighbouring communities and density of human influences exhibited no significant correlations with poaching density.

Analysis of the Corridor reserve poaching densities exhibited similar correlations between year-round poaching density and dry season poaching density. For example, elevation exhibited the strongest positive relationship with these two poaching densities while wet season poaching exhibited the strongest negative correlation with distance from roads and distance from provincial road (Table 3.4). Distance from waterholes was another factor that had a significant negative correlation with wet season poaching. Various factors exhibited positive correlations with dry season poaching and year-round poaching including distance from rivers, distance from human influences, distance from roads, distance from provincial road and slope. Density of waterholes had no significant relationship with wet season poaching or dry season poaching, however it had a significant positive correlation with year round poaching. No significant relationship was evident for distance from the HiP boundary, distance from neighbouring communities, density of human influences and density of roads for any of the poaching densities.

Table 3.3: Spearman correlation co-efficient (r) and statistical significance (p) between density of poaching and biophysical and anthropogenic factors within iMfolozi Game Reserve

Factor	Year Round Poaching (n=50)		Wet Season Poaching (n=28)		Dry Season Poaching (n=22)	
	r	p	r	p	r	p
Density of roads	-0.6644	<0.0001	-0.7044	<0.0001	-0.5664	0.0060
Distance from roads	0.6616	<0.0001	0.7028	<0.0001	0.5901	0.0038
Distance from human influences	-0.5344	<0.0001	-0.5899	<0.0001	-0.5697	0.0056
Distance from provincial road	0.5286	<0.0001	0.5353	0.003	0.4681	0.0280
Density of rivers	0.4541	<0.0001	0.7143	<0.0001	0.3134	0.1555
Slope	-0.4355	0.0016	-0.4098	0.0303	-0.5607	0.0066
Distance from rivers	-0.3991	0.0041	-0.4917	0.008	-0.3032	0.1702
Distance from waterholes	-0.3447	0.0143	-0.6004	<0.0001	-0.2998	0.1752
Density of waterholes	0.3049	0.0313	0.5011	0.0066	0.1601	0.4766
Distance from the HiP boundary	0.2609	0.0674	0.4781	0.0101	0.0833	0.7125
Elevation	-0.2098	0.1437	-0.5478	0.0026	0.4891	0.0209
Distance from neighbouring communities	0.1959	0.1730	0.1683	0.3919	0.0412	0.8556
Density of human influences	0.1606	0.2655	0.2166	0.2683	0.1126	0.6178

Table 3.4: Spearman correlation co-efficient (r) and statistical significance (p) between density of poaching and biophysical and anthropogenic factors within Corridor Reserve

Factor	Year Round Poaching (n=23)		Wet Season Poaching (n=9)		Dry Season Poaching (n=14)	
	r	p	r	p	r	p
Elevation	0.8478	<0.0001	-0.3500	0.3558	0.9736	<0.0001
Distance from rivers	0.7540	<0.0001	-0.5500	0.1250	0.9242	<0.0001
Distance from human influences	0.6887	0.0003	0.1500	0.7001	0.5385	0.0469
Distance from roads	0.6737	0.0004	-0.8208	0.0067	0.8154	0.0004
Distance from provincial road	0.6737	0.0004	-0.8208	0.0067	0.8154	0.0004
Distance from waterholes	-0.5702	0.0045	0.7500	0.0199	-0.5340	0.0492
Density of waterholes	0.5380	0.0080	0.5250	0.1467	0.1600	0.5848
Density of rivers	0.5366	0.0082	0.6000	0.0876	-0.6923	0.0061
Slope	0.4980	0.0156	-0.4500	0.2242	0.5387	0.0469
Distance from the HiP boundary	-0.1907	0.3834	-0.6500	0.0581	-0.4769	0.0847
Distance from neighbouring communities	-0.1511	0.4913	0.1541	0.6922	-0.4769	0.0847
Density of human influences	-0.1215	0.5807	-0.6000	0.0876	-0.0418	0.8872
Density of roads	-0.1127	0.6087	-0.6000	0.0876	-0.0418	0.8872

Land cover within the HiP is predominantly grassland, occupying approximately 40% of the reserve. Other land cover types include bushland (18%), woodland (15%), dense bush (12%) mixed grassland/bush clumps (11%), forest (<2%), water (<2%), wetlands (<1%), bare sand/erosion (<1%) and settlements (<1%) (Table 3.5). Year-round, wet and dry season locations of rhino poaching incidents were overlaid on land cover in the study area, revealing areas of low and high frequency of poaching in the HiP. (Table 3.5). Grassland registered the highest frequency of poaching incidents all year round and in the dry season (34 and 20 incidences respectively). Grassland also experienced the highest density of poaching during the dry season, while in the mixed grassland/bush clumps, the highest density occurred year-round and during the wet season (Table 3.5). These two vegetation types account for between 64.1% and 70.7% of the total poaching incidents compared with between 29.3% and 35.9% in the bushland, woodland and dense bush vegetation types. No recorded poaching occurred within forest, wetlands, bare sand/erosion, water or settlements.

Table 3.5: Relationship between rhino poaching and land cover in the HiP

Land cover			Year-round poaching		Wet season poaching		Dry season poaching	
Land cover	Area (km^2)	%	Frequency	Density	Frequency	Density	Frequency	Density
Forest	19.15	<2%	0	0.000	0	0.000	0	0.000
Woodland	136.73	15%	10	0.073	4	0.029	6	0.044
Grassland	354.23	40%	34	0.096	14	0.040	20	0.056
Mixed grassland / bush clumps	97.99	11%	20	0.204	15	0.153	5	0.051
Dense bush	103.86	12%	4	0.039	3	0.029	1	0.010
Bushland	163.11	18%	12	0.074	5	0.031	7	0.043
Bare sand/erosion	1.84	<1%	0	0.000	0	0.000	0	0.000
Settlements	0.92	<1%	0	0.000	0	0.000	0	0.000
Wetlands	1.70	<1%	0	0.000	0	0.000	0	0.000
Water	15.43	<2%	0	0.000	0	0.000	0	0.000
Total	894.96	100%	80	0.089	41	0.046	39	0.044

3.5 Discussion

This study sought to understand and explain the spatial and temporal patterns of rhino poaching within the HiP. Based on the number of rhinos poached, the increase of rhino poaching within the HiP from 2008 increased at an average rate of 48% annually. This appears to coincide with the national South African average increase of 50% of rhino poaching since 2008 that was expressed by Biggs et al. (2013) and Emslie et al. (2012). This increase in poaching is attributed to the increased demand for rhino horn by countries such as Vietnam and China (Ellis, 2005; Milliken & Shaw, 2012; Trendler, 2011). Studies reveal that the demand for rhino horn in Vietnam is related to social status, citing the main culprits as the influential, well-educated and successful people within the Vietnamese society who value the horn as a symbol of wealth, power, and reassurance of social standing (Caldwell, 2013; Environmental Investigation Agency, 2013; Milliken & Shaw, 2012; Smith, 2012; Tanner, 2015). These among others are considered catalysts for the increased demand for rhino horns since 2008.

The most intense period for poaching within the HiP are the months corresponding with the late dry season and early wet season, reaching peaks in the months of August and September. This observation may be attributed to less dense vegetation in the dry season providing good visibility and easier mobility for poachers (Balfour, 2009; Cromsigt et al., 2009). Poaching levels appear lowest during the months of March and April which correspond with the late wet season and early dry season. During this time, water and forage availability increases resulting in thicker and denser vegetation cover and poachers may find it difficult to locate rhinos.

The observed higher frequency and density of incidents in mixed grassland/bush clumps and grassland and lower frequencies within bushland, woodland and dense bush could be attributed to the fact that poaching incidences are more likely to occur in areas where mobility of tracking and visibility of rhinos is enhanced and thus areas such as grasslands may be targeted due to the lack of thick dense vegetation which may obstruct both visibility and mobility (Gray & Bond, 2013). The fact that between 64.1% and 70.7% of total poaching incidences occurred within grassland and mixed grassland/bush clumps may also explain the high proportion of white rhino poached as opposed to black rhino. White rhino are grazers and feed mainly on grasslands (Perrin & Brereton-Stiles, 1999) while black rhinos are browsers and prefer to spend their time feeding in woodlands and bushlands where they feed on small shoots, leaves and twigs from woody plants (Skinner & Chimimba, 2005) hence white rhinos are more likely to be poached than black rhinos.

Results from the hot spot analyses illustrate that wet season poaching is mainly concentrated within the iMfolozi Game Reserve and as the dry season progresses, hot spots expand into the Corridor Reserve. These poaching patterns may be attributed to the movement of the white rhino between the wet and the dry seasons for feeding. Studies conducted by Hebbelmann (2013), Owen-Smith (1988) and Perrin and Brereton-Stiles (1999) conclude that the spatial distribution of food (both quality and/or availability) is one of the main drivers behind the seasonal expansion/shift of rhinos' movements within the HiP. Owen-Smith (1988) found that white rhinos during the wet season concentrated their grazing on short grass within the grasslands of the iMfolozi Game Reserve. As the dry season progresses and the availability and quality of short grasses declines on the gentle terrain, white rhinos may move up into hill slopes to graze on the remaining taller grasses (Owen-Smith, 1988). Further observations supporting these findings are provided by results of correlation between poaching incidences and elevation and slope. For example, wet season poaching within the iMfolozi Game Reserve negatively correlated with elevation while dry season poaching positively correlated with elevation. Dry season and year-round poaching densities within the Corridor reserve were also positively correlated with elevation. Slope was also found to be positively correlated with dry season poaching and year-round poaching within the Corridor reserve but negatively correlated within the iMfolozi Game Reserve which further corresponds with studies by Owen-Smith (1988) and Perrin and Brereton-Stiles (1999) that rhinos feed on grasses on gentle terrain during the wet season and progress into the higher, steeper slopes of the Corridor Reserve during the dry season.

Analysis results determining the role of other factors in poaching patterns revealed that some factors may influence poaching patterns differently depending on where they occur spatially or temporally. For example, within the iMfolozi Game Reserve, the strongest negative correlation occurred between poaching density and road density within the park. This observation as well as the positive correlation between poaching and distance to park roads correspond with findings by Kyale (2006) and Leader-Williams et al. (1990) suggesting that poaching tends to occur in remote areas away from road networks as poaching activities have a greater chance of being undetected by patrolling rangers. Much of the iMfolozi Game Reserve is a designated Wilderness Area where no formal road structures are erected and patrols are either taken on foot or horseback, thus making this area a particular hotspot for poaching. The density of park roads does not play a significant role in the Corridor reserve however distance from park roads and distance from the provincial road influences poaching patterns within the Corridor Reserve. Although year round poaching and dry season poaching is positively correlated with distance from provincial road, it is still important to note that these poaching incidences did all occur within 5 kilometres of the public provincial road (exact positions of poaching incidences cannot be displayed as previously mentioned). This observation could be related to the road providing easy and quick access in and out of the park in relatively short periods of time. This is supported by Carnie (2016) who maintains that Ezemvelo KZN Wildlife, the custodian of the HiP recently acknowledged that the public provincial district road running through the reserve has added to the increasing incidences of poaching within the park.

A noteworthy finding is exhibited by the distance to human influences and the density of poaching within iMfolozi Game Reserve as this relationship is negative. This negative correlation seems to contradict the assumption that poachers confine their activities to remote areas away from park lodges, offices or ranger bases where they are unlikely to be detected and suggests that poaching occurs close to aspects of human influence. However, Maingi et al. (2012) who found similar results provided a plausible reason for this observation suggesting that poaching activities are more likely to be discovered close to human influences as these areas are occupied/patrolled by humans and it may be likely that poaching activities in remote areas may go undiscovered and hence could produce the results found.

The insignificant negative correlation between dry season poaching and distance to rivers and insignificant positive correlation between dry season poaching and density of rivers within the iMfolozi Game Reserve suggests that the presence of rivers does not influence patterns of poaching. Similar results revealing insignificant negative relationships were exhibited between density of waterholes, distance from waterholes and poaching densities within iMfolozi Game Reserve. This appears to be also true for poaching incidences within the Corridor Reserve where results show that both dry season poaching and year round poaching occur further away from rivers. These results may be explained by the fact that rhinos are not water-dependent (Hebbelmann, 2013; Lush et al., 2015; Odendaal, 2011; Owen-Smith, 1988). In addition, Owen-Smith (1988) found that during summer (wet season) rhinos drink daily, but during the dry season (winter) rhinos can go for periods of several days without water.

Distance from the HiP boundary and distance from neighbouring communities had insignificant relationships with poaching within the Corridor Reserve and the iMfolozi Game Reserve, suggesting that these factors do not influence poaching patterns as much as other biophysical and human factors considered in this study.

3.6 Conclusion

This study sought to assess the use of geographic information systems in understanding the factors that explain the spatial and temporal distribution of rhino poaching in the Hluhluwe-iMfolozi Park, KwaZulu-Natal based on available rhino poaching data (1990 – 2013). The study revealed poaching hot spots, as well as spatial and temporal variation in poaching incidences. Biophysical and human variables were found to influence poaching densities differently depending on where they occurred spatially or temporally. Feeding habits of rhinos, park roads, elevation and slope were the most important factors influencing poaching densities within the HiP. The successful use of GIS in this study validates its potential as a geospatial tool for understanding these patterns of poaching and could lay a foundation for more research on rhino poaching patterns to be performed. The present study recommends that the collection and capturing of poaching data needs to be improved as some of the poaching incidences had to be removed from the analyses as they lacked sufficient spatial or temporal data. This study could only assess temporal patterns seasonally due to the difficulty of obtaining more detailed information such as date or time of the poaching incidents. Determining the exact day of the poaching incident is difficult as rangers may only find a rhino carcass days or even weeks after the poaching occurred as a result of the vast expanse of area being patrolled. With better data capture, a better understanding of the poaching patterns both spatially and temporally could be achieved. Correlation analyses within the Corridor Reserve of the HiP in this study was done using relatively small sample sizes (<30), future research on larger sample sizes would better validate the findings found. Understanding these poaching patterns is crucial for future anti-poaching planning and mitigation of poaching activities with protected areas.

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CHAPTER FOUR

ANALYSIS OF RHINO POACHING INCIDENCES AND MANAGEMENT STRATEGIES IN SOUTH AFRICA: A SYNTHESIS

4.1 Introduction

The illegal hunting and global trade in wildlife and wildlife products is a multi-billion-dollar industry estimated to be worth US$50-US$150 billion per year (UNEP, 2014). This transnational, highly organised crime continues to threaten the survival of many endangered species globally (Glaubitz, 2015; TRAFFIC, 2008; UNEP, 2014). The five species of rhinoceros (rhino) are such threatened species with all five species appearing on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2014). The poaching of rhinos for their horns is currently in the spotlight of biodiversity conservation discourse due to escalated increase in poaching incidences in Africa. Poaching is said to have increased consecutively for the past six years resulting in at least 5 940 African rhinos being killed from 2008 (IUCN, 2016). Although poaching has always existed, Biggs et al. (2013) and Emslie et al. (2012) maintain that since 2008 rhino poaching has markedly escalated, particularly in South Africa that has experienced an average increase in poaching of 50% each year. If poaching continues to increase as it has done over the past few years the rhino population within South Africa may begin to decline as early as 2016 (Emslie, 2012).

This bleak rhino situation is compounded by the continuous demand for rhino horns by countries such as Vietnam and China (Ellis, 2005; Milliken & Shaw, 2012; Trendler, 2011), where rhino horns are said to be used for various purposes (‘t Sas-Rolfes, 2012; Caldwell, 2013; Environmental Investigation Agency, 2013; Milliken & Shaw, 2012; Smith, 2012; Tanner, 2015).

Although law enforcement in the field is considered as fundamental in the attempt to reduce poaching incidences (Akella & Cannon, 2004; African Wildlife Foundation, 2014; Critchlow et al., 2015; Critchlow et al., 2016; Hilborn et al., 2007; Jachmann, 2008; Maingi et al., 2012; Plumptre et al., 2014; Sibanda et al., 2015), this can be most successful when a pattern of rhino poaching is evident, aiding in more focused patrols and a wiser use of resources (Critchlow et al., 2015; Maingi et al., 2012; Sibanda et al., 2015).

In addition to understanding poaching pattern in time and space, the right combination of strategies (Bega, 2015; Cheteni, 2014; Department of Environmental Affairs (DEA), 2013; Duffy et al., 2013; Ferreira et al., 2014; Guedes, 2016; Milliken & Shaw, 2012; Sollund & Maher, 2015) is fundamental to winning the battle against rhino poaching. The main aim of this study was therefore to analyse the spatial and temporal patterns of rhino poaching in Hluhluwe-iMfolozi Park and to critically review suggested strategies aimed at reducing rhino poaching in South Africa.

To achieve this aim, the objectives were:

1. To investigate how rhino poaching varied seasonally and annually.

2. To determine the spatial patterns of poaching incidences within Hluhluwe-iMfolozi Park and in turn identify poaching hotspots.

3. To investigate the relationship between the observed patterns of poaching and biophysical and human variables.

4. To analyse both past, current and proposed management strategies that are relevant in reducing rhino poaching using empirical literature from different scholars.

5. To examine the effectiveness of past and current strategies in reducing rhino poaching.

6. To determine which strategy or combination of strategies is best suited to reduce rhino poaching.

4.2 Analysing the spatial and temporal patterns of rhino poaching

This section discusses how objectives 1 to 3 were achieved and thus the first of the main aim (analysing the spatial and temporal patterns of rhino poaching in Hluhluwe-iMfolozi Park). Understanding the spatial and temporal patterns of rhino poaching is essential for the effective and efficient deployment of anti-poaching patrols in protected areas. In this dissertation, rhino poaching incidences within Hluhluwe-iMfolozi Park between 1990 and 2013 were examined to investigate the spatial and temporal patterns of poaching using GIS.

Results show that rhino poaching within Hluhluwe-iMfolozi Park started escalating from 2008 at an average rate of 48% annually (Figure 3.2) and appears to coincide with the national South African average increase of 50% (Emslie et al., 2012). This increase in poaching is attributed to the increased demand for horn by countries such as Vietnam and China where it is used for medicinal purposes as well as a to display social status namely wealth, power and to reassures one's social standing (Caldwell, 2013; Environmental Investigation Agency, 2013; Milliken and Shaw, 2012; Smith, 2012; Tanner, 2015).

The most intense period for poaching within the Hluhluwe-iMfolozi Park are the late dry season and early wet season months (Figure 3.3), while the least intense period occurred in the late wet season portraying the role of seasonal vegetation in poaching activities. Poor vegetation cover in the dry season provides good visibility and easier mobility for poachers while dense vegetation in the wet season may prove more difficult to track and poach rhinos (Balfour, 2009; Cromsigt et al., 2009).

The observed higher proportion of incidents in mixed grassland/bush clumps and grassland vegetation (Table 3.4) could be attributed to the fact that poaching incidences are more likely to occur in areas where mobility of tracking and visibility of rhinos is enhanced and thus such areas are targeted due to the lack of thick dense vegetation which may obstruct both visibility and mobility (Gray & Bond, 2013). The fact that 68% of total poaching incidences occurred within grassland and mixed grassland/bush clumps may also explain the high proportion of white rhino poached as opposed to black rhino as white rhinos are grazers and feed mainly on grasslands (Perrin & Brereton-Stiles, 1999) while black rhinos are browsers and prefer to spend their time feeding in woodlands and bushlands where they feed on small shoots, leaves and twigs from woody plants (Skinner & Chimimba, 2005).

Results from the hot spot analyses illustrate that wet season poaching is mainly concentrated within the iMfolozi Reserve and as the dry season progresses, hot spots expand into the Corridor Reserve. These poaching patterns may be attributed to the movement of the white rhino between the wet and the dry seasons as demonstrated by studies conducted by Hebbelmann (2013), Owen-Smith (1988) and Perrin and Brereton-Stiles (1999) that conclude that the spatial distribution of food (both quality and/or availability) is one of the main drivers behind the seasonal expansion/shift of rhinos' movements within HiP. Owen-Smith (1988) found that white rhinos during the wet season concentrated their grazing on short grass grasslands of the iMfolozi reserve. As the dry season progresses and the availability and quality of short grasses declines on the gentle terrain, white rhinos may move up into hill slopes to graze on the remaining taller grasses of the slopes (Owen-Smith, 1988), reiterating this study's poaching patterns.

Biophysical and human variables were found to influence poaching densities differently depending on where they occurred spatially or temporally. Habitat selection and feeding habits of rhinos, park roads, elevation and slope were the most important factors influencing poaching densities within HiP**.**

4.3 A critical review of strategies to reduce rhino poaching in South Africa

This section discusses how objectives 4 to 6 were achieved leading to the second part of the main aim (a critical review of suggested strategies aimed at reducing rhino poaching in South Africa). Although many different conservation strategies to reduce the number of poaching incidences has been suggested, there appears to be controversy and confusion on what works best, thus putting rhino conservation at risk. These anti-poaching strategies include legalisation of international trade in rhino horn, demand reduction strategies, dehorning, translocation, improving law enforcement, local community involvement and political will (DEA, 2013; Duffy et al., 2013; Ferreira et al., 2014; Mukwazvure & Magadza, 2014; Sollund & Maher 2015).

For a reduction in rhino poaching to materialise, a clear vision of what strategies complement each other is needed. This dissertation has attempted to address past, present and proposed strategies, their effectiveness in reducing poaching and their shortcomings. A suggested conceptual framework has been suggested on the combination of anti-poaching strategies that could be effective in reducing rhino poaching. Thus the implementation of an integrated, holistic approach, combining different strategies working concurrently is recommended in this study as the best strategy to curb poaching.

An examination of selected anti-poaching strategies as presented in this paper suggests that tackling the problem of poaching by reducing demand is essential in any future policies or plans that are to be adopted or implemented. Reducing rhino poaching cannot be achieved without demand reduction strategies such as education and awareness campaigns, political pressure and sanctions, development and implementation of legislation as well as the encouragement of substitutes.

Involving the local community that surround parks and protected areas is another crucial element that cannot be overlooked in the attempt to curb rhino poaching. Local community participation in poaching is a manifestation of problems caused by the need for cash, lack of viable alternatives, lack of understanding of the importance of conservation, and the lack of good relationships between community members and protected area authorities. Therefore, the recognition and treatment of these causes have to be realised before any success in curbing poaching can be expected. Benefit sharing and community integration activities where local communities begin to value conservation, will aid to discourage poaching.

Corruption in different forms and levels has also been identified as a key enabler of poaching and illegal trade, as well as an important source of resilience for organised criminal groups involved in such crimes. Addressing this issue could greatly assist in reducing corruption linked with wildlife crimes.

Although legalisation of rhino horn trade has been advocated by various stakeholders as a sustainable strategy to reduce rhino poaching by supplying the market and reducing the black market price of rhino horn and thus reduce poaching, this outcome is not guaranteed as there is a current lack of knowledge and understanding of the current and future demand if trade were to be legalised. There is also the uncertainty that the legal trade will not simply replace the illegal trade and that perhaps both illegal and legal trade will run simultaneously and thus not achieve the poaching reduction objectives desired. Laundering has also been suggested as a potential problem with legalising trade in rhino horn as illegal traffickers may pass their illegal rhino horn as legal horn, and as many cases of corruption in the rhino horn trade already exist, laundering will present a serious risk to the legitimacy of rhino horn trade. There are further suggestions that legalising trade will have a detrimental impact on the efforts already made to reduce demand (by making the purchase of rhino horn socially unacceptable), and may also legitimise such unproven theories about the medicinal value of the horn. Since the outcome of rhino horn trade legalisation is unclear, the precautionary principle provides a wiser course of action as uncertainty surrounds the suggested legalisation in rhino horn trade.

4.4 Conclusion

The main focus of this dissertation was to analyse the spatial and temporal patterns of rhino poaching within Hluhluwe-iMfolozi Park using GIS as well as to critically analyse the management strategies that are being suggested to reduce rhino poaching. The successful use of GIS in this dissertation validates its potential as a geospatial tool for understanding the spatial and temporal distribution patterns of rhino poaching within protected areas. As law enforcement is a significant cost expenditure within many protected areas, understanding these patterns is crucial for future effective and efficient deployment of anti-poaching patrols.

Since the reduction of rhino poaching is a complex and challenging task, law enforcement cannot act as a stand-alone deterrent for poaching and as shown in this dissertation, a combination of strategies that address all aspects of poaching need to work concurrently to decrease poaching levels. It is therefore apparent that conservation management strategies that work hand in hand with each other provide the greatest success against rhino poaching. Figure 2.1 illustrates this holistic approach, made up of four sub-approached namely the market approach, the environmental approach, the social approach and the legal approach, all aimed at curbing rhino poaching.

4.5 Recommendations

The paucity of research and literature on the patterns of rhino poaching reveal that GIS application in this field is still in its youthful stage. The successful use of GIS in this dissertation validates its potential as a geospatial tool for understanding patterns of rhino poaching and contributes to a foundation for more research on rhino poaching patterns to be performed. The present study also revealed gaps in data suggesting the need to improve data collection on poaching incidences. For example, some data had to be removed from the analyses because they lacked sufficient spatial or temporal components. Accurate data collection would lead to a robust analysis and a better understanding of poaching patterns to guide decisions aimed at reducing rhino poaching.

Due to the uncertainties addressed with the legalisation of rhino horn, more economic and market research needs to be done on consumer/end-user behaviour so as to inform proper legalisation on the issue. There seems to be inadequate knowledge of the existing market and demand for rhino horn, leading to uncertainty about whether supply can meet demand. For example, do rhino horns have any medicinal value? This provides an avenue of further research. More information is also needed on the financial and opportunity costs of setting up and managing a legal, regulated trade. Finally, political will, demonstrated by action and tackling issues of corruption is crucial for the future survival of rhino populations in South Africa.

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