Developing a management information system for coordinated predation management in South Africa

by

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Declaration

I declare that this thesis, hereby handed in for the qualification Doctor of Philosophy in Wildlife in the Faculty of Natural and Agricultural Sciences at the University of the Free State, is my own independent work and that I have not previously submitted the same work for a qualification at another university/faculty. I cede copyright of the thesis in favour of the University of the Free State.

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Dedicated to loved ones lost – Your memory
lives on in the wisdom you have passed onto us

“When we try to pick out anything by itself, we find it hitched to everything else in the Universe.”

– John Muir –

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Abstract

Predation on livestock and wildlife is the most prominent facet of human-wildlife conflict worldwide. Yet, it is the least understood, in part due to the disparity in methods used to collect data and report results relating to predation and predation management. Predation management is a highly controversial issue, and the lack of scientific information is a major concern and impediment for initiatives to devise effective and acceptable management strategies.

The purpose of this study was twofold: (a) to conduct a detailed farm-level investigation into predation vs predation management in areas where high levels of predation had previously been reported, and (b) to develop a tool to provide livestock farmers and wildlife ranchers with a means of reporting predation and practices employed to curb the impact of predation. Building on the groundwork laid by previous studies in South Africa, this study aimed to provide a basis for improving our understanding of the dynamics of human-predator conflict on farm level as well as on a larger scale in an attempt to address some of the current research gaps.

This study explored a succession of methods to collect information on predation and predation management on farm-level and develop a tool to collect such data. Initially, questionnaires were used to collect data, concurrent with the process of developing a digital data collection tool. The data collected by means of the questionnaires were used to test this tool (two mobile device applications). The challenges presented during the study and those associated with other methods of data collection played a central role in the data collection methodology developed in the study.

At the onset of the study, questionnaires were used to collect information on predation experienced, predator control methods practised, as well as other factors known to influence predation, such as demographic information, physical and managerial characteristics of a farm, and husbandry practices. Though showing potential to provide invaluable information, the questionnaire methodology used in the early phases of this study highlighted fundamental issues regarding the use of conventional data collection methods and the lack of coordinated predation management systems that thwarted the objectives initially set for this study. Consequently, the focus also

shifted toward developing a Management Information System (MIS) through which predation management data may be used to develop sound mitigation strategies and, ultimately, inform Best Management Practices.

This thesis discusses the development and value of digital data collection methods, specifically mobile device applications, for use in predation management. It also highlights the importance of coordinated action and institutional memory to ensure a structured and focused approach to inform improved predation management strategies in South Africa. To achieve this goal, a system of coordinated predation management must have an MIS at its core.

Practical methodologies were developed to manage predation, focusing on more effective technology and procedures to collate relevant information for incorporation into a national database as part of an MIS. Data collected with such methodology presents the opportunity to assist authorities, landowners and other role players with a notable range of coordinated predation management options. The effective and sustainable management of mesopredators poses a range of complicated and varying challenges for responsible authorities and landowners, in South Africa but also worldwide.

The outcome of this study is an important and valuable contribution to the knowledge base and insights available to manage damage-causing predators more sustainably. It laid a firm foundation for a comprehensive MIS to inform predation management in South Africa.

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List of acronyms

ALPRU	African Large Predator Research Unit
CCP	Canis-Caracal Programme
CPeace	Centre for Conservation Peacebuilding
DARDLR	Department of Agriculture, Rural Development and Land Reform
DEFF	Department of Environment, Forestry and Fisheries
DEDEAT	Department of Economic Development, Environmental Affairs and Tourism
DEAT	Department of Environmental affairs and Tourism
ECPTA	Eastern Cape Parks and Tourism Agency
EDTA	Department of Economic Development, Tourism and Environmental Affairs
GDARD	Gauteng Department of Agriculture and Rural Development
GIS	Geographic Information Systems
HWCC	Human-Wildlife Conflict Collaboration
MIS	Management Information System
NPAPC	National Problem Animal Policy Committee
NRF	National Research Foundation
NWGA	National Wool Growers' Association of South Africa
PMC	Predation Management Centre
PMiC	Predation Management Information Centre
PMF	Predation Management Forum
RPO	Red Meat Producers' Organisation
SAMGA	South African Mohair Growers' Association
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Management
UFS	University of the Free State
USDA-APHIS	US Department of Agriculture, Animal and Plant Health Inspection Service
WRSA	Wildlife Ranching South Africa
WS	Wildlife Services

1 Introduction

Predation on livestock by black-backed jackal (*Canis mesomelas*) and caracal (*Caracal caracal*) is common and considered a major challenge in southern Africa (Janse van Rensburg, 1965; Hey, 1964; 1967; 1974; Lensing & Joubert, 1976; Rowe-Rowe, 1976; Grobler, 1981; Stuart, 1982; Bernard & Stuart, 1987; Brand, 1993; Bingham & Purchase, 2002; Melville *et al*., 2004; Kamler *et al*., 2008; Du Plessis, 2013; Balfour & Kerley, 2018; De Waal, 2020). The lack of scientific information on these two damage-causing predator species is often stated as a major concern and impediment for initiatives to devise meaningful predation management strategies (Du Plessis *et al.*, 2015; Tambling *et al.*, 2018), but in the absence of current institutional memory on human-predator conflict (De Waal, 2009; 2020; Bergman *et al.*, 2013;) such concerns may pale into insignificance.

Control of damage-causing predators is a highly controversial issue (Van Ballenberghe, 2004; Bodenchuk *et al*., 2013). Despite some reports on apparent population increases and range expansion by black-backed jackal and caracal (Hey, 1967; Pringle & Pringle, 1979; Stuart, 1982; Marker & Dickman, 2005; Avenant & Du Plessis, 2008), and claims by livestock farmers that predation on livestock by these predators is increasing (De Waal, 2009), critics of predator control often refute losses reported by livestock farmers (Shelton, 2004). They argue that the impact of predation on the livestock industry is exaggerated, that there is no clear evidence that predator control is reducing losses, that predation is a natural phenomenon necessary for maintaining ecological balance, and that most losses are balanced by the advantages of predators in controlling the populations of species that damage veld and crops (Connolly, 1978). There is an urgent need for more relevant information to inform predation related issues (Sacks *et al.*, 1999; Du Plessis *et al.*, 2015).

The fundamental principle behind managing human-predator conflicts should be to reduce livestock predation and subsequent retribution killing (Jaeger, 2004; Davie *et al.*, 2014). Therefore, mitigation of human-predator conflict requires a clear understanding of the nature of the conflict, as well as the underlying anthropogenic and environmental drivers (Thorn *et al.*, 2012; 2013; Du Plessis *et al.*, 2015).

This chapter discusses some of the major aspects characterising human-predator conflict, especially regarding predation by black-backed jackal and caracal in South Africa. It is against this background that the succession of data collection methods used in this study attempted to address the lack of institutional memory regarding predation management in South Africa.

1.1 Background

A large part of South Africa comprises arid and semi-arid natural pasture (veld), which is best suited as food source for herbivorous animals such as ruminants (De Waal, 1990). Hence, livestock farming and wildlife ranching activities are practised on comparable natural resources, often as neighbours or on the same property; therefore, these activities will be affected by the same environmental factors, including the effects of predation (De Waal, 2015). Previously, information on predation was not readily available (Cilliers, 2006; De Waal, 2009; Avenant *et al.*, 2006; Bergman *et al*., 2013), but recently it has been shown that wildlife ranches are also negatively affected by predation (Constant *et al.*, 2015; Schepers, 2016), similar to livestock farms.

The livestock farming and wildlife ranching sectors contribute substantially to food security, play a vital role in employing rural communities, form the backbone of South Africa's socio-economy through links up and down the chain to many other industries, are vital sources of foreign exchange, and also play an integral part in the conservation of biodiversity (Thorn *et al.*, 2012; Meissner *et al.*, 2013). The livestock sector, and specifically extensive livestock production enterprises, is characterised by slim profit margins; therefore, predation on livestock will negatively impact already struggling enterprises (Lawson, 1989; Knowlton *et al.*, 1999; Mitchell *et al.*, 2004; Strauss, 2009; Conradie, 2012; Constant *et al.*, 2015).

Predators impose economic costs through their direct impact on commercial livestock and marketable wildlife production (Bradley & Fagre, 1988), as well as through competition with humans in rural communities over livestock and wild game (Berger, 2006). Livestock farmers suffer financially as a result of direct losses and also as a result of the loss of potential income (Rowe-Rowe, 1976) due to production losses and control expenses (Allen & Fleming, 2004; Strauss, 2009; Van Niekerk, 2010; Badenhorst, 2014).

Consumers are also directly affected by losses due to predation because they may pay more as a result of reduced supplies of livestock products (Connolly, 1978; Jones, 2004). Furthermore, additional adverse effects on the economy may include increased job losses (Strauss, 2009; Conradie, 2012), decreased animal production, increased production costs (Jones, 2004), the negative impact on food security and increased taxes (Du Plessis, 2013). According to Shwiff & Bodenchuk (2004), the costs of management include direct expenditures by farmers for management programmes, governmental expenditures for management and compensation programs, farmer and governmental costs associated with preventing predation, and societal values associated with the predators removed.

Reflecting on a specific period in South Africa, namely the mid-1960s, Hey (1967) stated that the black-backed jackal, while still being the primary predator of sheep, is relatively well controlled with techniques that include hunting with packs of hounds, and the use of traps, poisons and the coyote getter. However, despite control efforts, it seems that livestock losses due to predation have not declined and the impact is widespread (Grafton, 1965; Ferguson, 1980; Stuart, 1982; Bernard & Stuart, 1987; Stuart & Hickman, 1991; Brand, 1993; Melville *et al.*, 2004; Gunter, 2008; Strauss, 2009; Van Niekerk, 2010; Badenhorst, 2014; Schepers, 2016). This may be ascribed to the fact that while many control methods are selective at the species level, they are not particularly helpful at removing the specific individuals responsible for the damage (Conner *et al.*, 1998; Avenant & Du Plessis, 2008; Baker *et al*., 2008; Du Plessis, 2013; Du Plessis *et al*., 2018).

In addition to the direct and indirect predation losses, smaller profit margins due to increasing input costs and low product price increases may induce negative social and cultural impacts (Strauss, 2009; Constant *et al.,* 2015). Affected farmers' increasing concerns about their future in the industry may create conflict situations that limit human tolerance of carnivores and provoke revenge killings (Herfindal *et al*., 2005; Deacon, 2010). The desperation of livestock farmers to curb predation losses has led to blanket control of predators in the past. However, it is widely concluded that such an unselective blanket control strategy is ineffective (Hey, 1964; Stuart, 1982;

Moolman, 1986; Allen & Sparkes, 2001; Blejwas *et al.,* 2002; Avenant & Du Plessis, 2008; Baker *et al*., 2008; Du Plessis, 2013).

The numbers and distribution of black-backed jackals and caracals appear to be increasing (Avenant & Du Plessis, 2008) and as a consequence, also their impact as damage-causing predators on livestock farms and wildlife ranches (Van Niekerk, 2010; Badenhorst, 2014; Constant *et al.,* 2015; Schepers, 2016).

1.2 Scientific information in human-predator conflict management

Human population growth results in increasing human encroachment on natural habitats, which leads to habitat loss, and consequently, increasing conflict between humans and wildlife (Inskip & Zimmermann 2009; Constant *et al.*, 2015). Predation on livestock is the most commonly reported aspect of human-wildlife conflict worldwide (Macdonald & Sillero-Zubiri, 2002; Baker, 2008). Management of such conflicts can only be accomplished if the dynamics of the conflicts and management methods are considered and understood (Shivik, 2004; Davie *et al.*, 2014; Du Plessis *et al*., 2015). Science plays a fundamental role in predation management by improving our understanding of predator-livestock interactions through appropriate research.

Increased predation on livestock and the resulting negative economic impacts have been cited as the most important reasons for the decline of the small livestock industry in the USA (Connolly, 1978; Owens, 1987; Knowlton *et al.*, 1999; Bromley & Gese, 2001; Blejwas *et al.*, 2002; Nunley, 2004; Houben, 2004; Shelton, 2004; Sacks *et al.*, 1999; McAdoo & Glimp, 2000) as well as Australia (Allen & Fleming, 2004). The impact on the economy, along with the inability of farmers to solve such problems themselves (Lowney *et al.*, 1997), ultimately led to the establishment of official, coordinated animal damage control programmes in these countries to manage the damage caused by predators.

In the past, control of predators focused mainly on reducing predator populations. The heavy persecution and near-extermination of some damage-causing animals often gave rise to secondary problems with a much broader scope than that of the original problem, since such attempts were often conducted without scientific understanding of the various underlying factors that gave rise to the original problem (Anonymous,

1966; Lensing & Joubert, 1976). In some instances (particularly where mesopredators such as the black-backed jackal and caracal are concerned), these predators continue to thrive, with a perceived increase in population density and expansion of their distribution ranges to areas where they were not previously considered a threat to livestock production, despite such intensive control efforts (Fall, 1990; Marker & Dickman, 2005). The ecological, social and economic sustainability of the efforts were often questionable (Avenant & Du Plessis, 2008; De Waal, 2009).

Scientific data assisted the initiation of government-supported conflict management programmes in the USA (Connolly, 1981; Fichtner, 1987; Benymanz, 1989; Messmer *et al.*, 2001; Clay, 2007; Bruggers, 2009; Bodenchuk *et al*., 2013). The management of human-predator conflicts depends on identification, implementation, evaluation and continuous improvement of methods developed by research (Fall, 1990; Connolly, 1995; Messmer *et al.*, 2001); a process known as “adaptive management” (Du Plessis *et al.*, 2018). The use of such programmes is seen as an efficient and economical way to serve livestock farmers (Bodenchuk *et al*., 2000; Houben, 2004).

Science plays a fundamental role in understanding the root causes and assessing the impact of conflicts, as well as the development of alternative mitigation strategies (Messmer *et al.*, 2001; Redpath *et al.,* 2013). Other countries experiencing major conflict as a result of livestock predation have also implemented coordinated programmes to mitigate such conflicts (Examples - Canada: Yoder, 2000; France: Stahl *et al*., 2001; Italy: Dalmasso *et al.*, 2012; Australia: Allen & Fleming, 2004; Norway: Asheim & Mysterud, 2004; Alaska: Van Ballenberghe, 2004; Namibia: Marker & Boast, 2015; Botswana: Schiess-Meier *et al*., 2007; Bhutan: Sangay & Vernes, 2008; Mexico: Zarco-González *et al*., 2013). In these countries, science has helped develop management strategies tailored to specific regions and specific predator species, and advances in management continue to be made based on scientific procedures.

An essential aspect of such a programme is the data collected; in particular, the records kept of the situation regarding predation on livestock and predator management. Therefore, coordinated animal damage control programmes play a vital role in creating much needed institutional memory and developing more effective

methods of control, as well as policy formulation. Extensive research from Europe and North America showed that selecting and employing appropriate conflict mitigation strategies depends on knowledge of the local situation, which is determined by a range of inter-related factors (Thorn *et al.,* 2013).

Scientific information on the extent, spatial and temporal distribution of predation and its impact on the economy, trends or changes in predation and predation management, and the success and feasibility of specific management methods serve as a basis to devise human-predator conflict management strategies (Fall, 1990; Mertens & Promberger, 2001; Messmer *et al*., 2001; Mitchell *et al.*, 2004; Blaum *et al*., 2009; Du Plessis, 2013; Du Plessis *et al*., 2015). Drivers behind the conflicts, as well as intervention priorities, are identified by research to assure a sound biological basis for conflict mitigation (Fall, 1990; Treves *et al.,* 2004). For example, designing efficient predation management strategies requires among other things data on farm/ranch management practices and the damage caused by predators, as well as the associated costs (Mertens & Promberger, 2001).

Sustainable human-predator conflict management programmes require a sound understanding of the ecology of the animals involved in the conflicts; the ecological interactions between different species and in different ecosystems; the predation and associated management practices; the success, feasibility and economic impact of management methods to alleviate stock losses; and the effects of these methods on the behaviour and ecology of target animals (Du Plessis *et al*., 2015). In addition to the development of long-term, sustainable and profitable management systems (Howery & DeLiberto, 2004), an increased understanding of the human-predator conflicts has also played an important role in justifying restriction or elimination of undesirable predator control options such as toxicants (Messmer *et al.*, 2001).

1.3 The lack of data and its implications for human-predator conflict management

In the 1950s the apparent escalation of conflict between livestock farmers and damage-causing predators in South Africa led to the realisation that there is a need for comprehensive, continued research and a balanced scientific approach to predation management, as well as close liaison with other departments and institutions

to address livestock losses experienced by farmers (Van der Merwe, 1953; Hey, 1964; 1967; 1974; Anonymous, 1966; Stadler, 2006; De Waal, 2020).

Hence, government-supported animal damage control programmes were established in the erstwhile four provinces of South Africa during the 1950s until the early 1990s (Hey, 1964; 1967; Ferreira, 1988; Kingwill, 1993; Miller, 1993; Olivier, 1993; Lensing, 1993; Visagie, 1993; De Waal, 2020). These programmes assisted livestock farmers with the control of damage-causing predators and provided them with technical aid and extension programmes to reduce the impact of predation (Stadler, 2006; Gunter, 2008). Specific responsibilities included control of damage-causing animals by government subsidised hunt clubs, training of hunters and hound packs, breeding hounds, supplying hunt clubs with materials and equipment, as well as research and extension on predation management (Ferreira, 1988; Lensing, 1993; Miller, 1993; Olivier, 1993; Visagie, 1993; Stadler, 2006; De Waal, 2020). This approach ensured close cooperation between farmers, animal damage control specialists and government officials.

Government played an indispensable and leading role in these programmes regarding the way in which data was collected, and the volume of data collected. Animal damage control specialists employed by the hunt clubs were responsible for documenting the damage reported by farmers as well as the subsequent control of damage-causing animals (Gunter, 2008; De Waal, 2020). Research on the ecology and control of damage-causing animals and the development of control methods formed an integral part of this approach. However, this could still not create a clear picture of the situation regarding predation management on a broad scale in South Africa. Data recorded by the government-subsidised hunt clubs included livestock losses due to predation and predator control, but the way in which data was collected proved insufficient to conduct meaningful analysis (Gunter, 2008). The success of predation management appears to have been measured in terms of the number of predators killed, rather than a subsequent decrease in predation. Some reports of hunt clubs and official inspections exist in which hunters remarked that predators were under control and or predation had decreased in certain areas during specific times, but this was not confirmed by data (Kruger, 2019 - unpublished data). However, these coordinated activities were abolished in the late 1980s to early 1990s (Lensing, 1993). Predation management

continued on private initiative, with little incentive to document activities and very little, if any, coordination of these activities (De Waal, 2009; 2020; Bergman *et al*., 2013). As a result, there has been a marked decline in official focus on predation and research on damage causing animals in South Africa, especially regarding the black-backed jackal and caracal.

The research conducted to date covered most of the different aspects of predation management but was fragmented (De Waal, 2009). The few scientific studies focusing on predation by black-backed jackals and caracals before 1990 were mostly geographically and temporally isolated; each focusing on different aspects of predation, predator control and or ecology of the predators; and generally did not focus on the development of sustainable management strategies (Du Plessis, 2013; Du Plessis *et al*., 2015). The fragmented nature of the research resulted in a limited understanding of the ecology and management of these predators. Some of the earlier studies on predation management (Brand, 1989; Lawson, 1989) tried to incorporate as much of the relevant information, including the perceptions of farmers concerning the predation. However, these studies were conducted on a very small scale, and results concerning specific topics, such as farm management practices, were not always discussed. Furthermore, conducting opinion surveys during that time was considered by some as being unscientific. Recently, however, there has been a shift back to multidisciplinary studies (which include qualitative aspects such as opinion surveys) in predation management (Strauss, 2009; Thorn *et al.*, 2012; 2013; Du Plessis, 2013; Constant *et al*., 2015).

Little is still known about the actual extent of predation, and even less is known about the way in which predation management practices (non-lethal and lethal methods) affect future predation by the same or other predator species. Furthermore, very little is known regarding the relationship between these sympatric species, namely black-backed jackals and caracals (Avenant & Du Plessis, 2008; Du Plessis *et al*., 2015).

Recent surveys have incorporated substantial numbers of respondents (Van Niekerk, 2010; Badenhorst, 2014; Schepers, 2016) and provided valuable insights in the extent of livestock and wildlife predation as well as the negative impact on the economy in South Africa. However, calculation of such average loss rates does not adequately

portray the nature of predation, since the losses are not evenly distributed geographically or among farmers (Connolly, 1978; Linhart *et al*., 1979; Mitchell *et al.*, 2004). It is difficult to obtain accurate estimates of predation losses because of limitations and possible sources of bias associated with all known methods of loss assessment (Connolly, 1978; Knowlton *et al*., 1999). Nevertheless, such estimates of predation losses emphasise the need for animal damage management programmes that provide for efficient, economical means of resolving human-predator conflicts; promote methods that are effective, biologically sound and socially acceptable; and seek to reduce predation (Bluett *et al*., 2003).

Historical data examined by Gunter (2008) showed no evidence of efforts made by the animal damage control programmes to give an overview or summary of predation and predator control on a larger (provincial or even national) scale and over extended periods. This uncertainty regarding the actual success of these coordinated efforts to manage predation (whether or not control did reduce livestock losses due to predation) may also have been one of the contributing factors that led to the demise of the official support of the programmes responsible for the control of damage-causing animals during the early 1990s. Only recently has research on predation management started to gain more attention, and studies on predation management have become more prevalent and focussed (Gunter, 2008; Snow, 2008; Strauss, 2009; Anthony *et al.*, 2010; Van Niekerk, 2010; Smith, 2012; Thorn *et al.*, 2012; Van As, 2012; Thorn *et al.*, 2013; Du Plessis, 2013; Badenhorst, 2014; Murison, 2014; Constant *et al.*, 2015; Humphries *et al.*, 2015; Minnie, 2015; Jansen, 2016; Schepers, 2016; Drouilly *et al*., 2017; Nattrass & Conradie, 2018). Nevertheless, little progress has been made in terms of predation management on a national level (Blaum *et al*., 2009; Du Plessis, 2013; Carruthers & Nattrass, 2018).

The paucity of scientific information to substantiate frequent claims of increased livestock predation in South Africa necessitates exploring the extent and distribution of predation on livestock and wildlife, general predation patterns over large areas, as well as hotspots in specific areas in detail (Du Plessis *et al.*, 2015). If conflict between humans and the animals posing a threat to their livelihoods is to be addressed, more information is needed to inform studies in search of solutions to aid in mitigating such

conflicts. Such studies should preferably be following a multidisciplinary approach (Du Plessis, 2013; Constant *et al*., 2015; Thorn *et al*., 2012; 2013).

Well-documented information is needed because significant advances in predation management should be informed by knowledge of livestock and wildlife management practices, techniques to manage predation, predation patterns and predator behaviour, ecology, technology, and the effectiveness of different tools (Breck & Meier, 2004). Awareness can best be achieved by cooperation from all role-players, especially farmers experiencing the predation losses first-hand.

This study endeavours to continue the baselines set by the work of Gunter (2008) and Du Plessis (2013). The former emphasised the use of appropriate software in collecting and analysing data and suggested specific formats for the most important information that needs to be collected for human-predator conflict management and research on the subject. The latter identified gaps in research conducted to date on human-predator conflict and suggested how human-predator conflict management should be conducted in South Africa.

Gunter (2008) identified important shortcomings in the way in which hunt clubs have recorded predation management data in the past, and suggested a new format for collecting such information to build a database capturing such information for analysis with the aid of Geographic Information Systems (GIS). Furthermore, the historical data explored by Gunter (2008) lacked critical information on predation and predator control, impeding scientific analysis.

The present study is part of the Canis-Caracal Programme (CCP) which aims (Avenant *et al*., 2006), among others, to:

- Qualify and quantify the impact of predation in South Africa on the livestock farming and the wildlife ranching industries;
- Identify and evaluate the methods used to manage the damage-causing predators;
- Assess the role that management practices play on livestock farms and wildlife ranches regarding human-predator conflict; and

- Assist conservation authorities to formulate and implement appropriate policies on predation management.

With the Canis-Caracal Programme (CCP), it is hypothesised that human-predator conflict in South Africa can be mitigated, provided:

- Official support structures are in place to assist farmers and ranchers who are suffering losses due to predation.
    - Continuous training and extension should be available to those directly affected by predation and responsible for predation management, as well as to government structures providing technical support to farmers and ranchers.
- All aspects of predation management are coordinated.
    - Preventive management.
    - Corrective management.
    - Research.
        - Research gaps must be identified.
        - Scientists should collaborate research efforts to address research gaps.
    - Legislation.
    - Stakeholder involvement.
- Existing information is used to help inform mitigation strategies.
    - Information from the previously active systems of predation management in South Africa should be obtained and examined.
    - Current data regarding predation experienced and predation management practised on livestock and wildlife production units should be collected.

      Data should be collected nationally, in a standardised manner, and over long periods, allowing for evaluation and monitoring of all efforts at coordinated predation management.
- South Africa integrates its predation management programme with a more extensive programme of human-wildlife conflict management.
    - Join the global network of human-wildlife conflict.

1.4 Aim and objectives

This study aims to develop a methodology for collecting detailed, standardised predation management data to inform predation management in South Africa. To ensure that such data address the gaps in scientific information on predation management in South Africa and assist the formulation of Best Management practices, it provides guidelines for and assisted in the development of a Management Information System (MIS). Utilising such an MIS in a coordinated predation management programme will markedly aid in the development of locally relevant human-predator conflict management strategies based on an institutional memory informed by scientific data.

Continuing the groundwork laid by Gunter (2008) in developing a method for collecting and interpreting standardised data on predation management in South Africa, the general guidelines in this study may also have application further afield.

Longitudinal data (repeated measurements or observations over time – Nakai & Ke, 2009) are indispensable when measuring change in an outcome over time (Fitzmaurice *et al*., 2009). Inskip & Zimmermann (2009) also stressed the importance of standardised reporting techniques for the development of successful management strategies. Due to the myriad different facets involved in human-predator conflict management, it is virtually impossible to draw conclusions and make recommendations from small datasets, data from small areas, and or geographically or temporally isolated data. Therefore, it is necessary to collect information on a large scale and to monitor and compare different scenarios to be able to develop the most efficient management strategies.

The specific objectives of this study include:

- Identifying the primary factors to be considered in studying predation management;
- Developing a practical, fast and efficient method to collect standardised data on a large scale from those directly involved in conflicts to research predation management per production enterprise;
- Providing guidelines for incorporating such data-collection methods in an MIS and a coordinated predation management system in South Africa;

- Identifying the main obstacles encountered in the process of collecting data on predation management and providing guidelines to address it; and
- Providing guidelines for developing a system of coordinated predation management in South Africa based on current institutional memory acquired through and maintained by the use of an MIS.

Recently an initiative was launched at the University of the Free State (UFS) with the naming of the “Predation Management Centre (PMC)”. Pursuant to active interaction, the Predation Management Forum (PMF) mandated the UFS to establish a Predation Management Information Centre (PMiC) on their behalf and incorporate it as an integral part of the information management system which was developed by the PMC at the UFS (De Waal, 2017a). The goal of the CCP, and specifically the PMC, is to assist in the process of addressing important aspects in renewed efforts at mitigating human-predator conflict in South Africa.

1.5 Study outline

This study consists of seven chapters. Chapter 2 highlights the challenges faced by wildlife managers in the past, as well as the challenges currently faced in the field of predation management. Since many of these challenges are interlinked, they also have a profound impact on the collection of data for predation management. Therefore, Chapter 2 provides an extensive yet necessary description of the different aspects of a system of coordinated predation management. It follows the basic outline of the general hypothesis of the CCP described in Section 1.3.

Chapter 3 describes the process of developing a Management Information System (MIS) containing various documents, databases and equipment to facilitate coordinated predation management in South Africa. The succession of methods that culminated in the development of mobile device applications for collecting information on predation and predation management is discussed in Chapter 3.

The main focus of the study, however, is contained in Chapters 4 – 6. Chapter 4 describes the lessons learnt during the process of developing a tool to aid data collection in the field and highlights the underlying social aspects at play in the field of

human-predator conflict in South Africa. It provides background on the evolution in data collection from questionnaires to mobile device technology and the potential of detailed data collected on farm level with the aid of modern technology and addresses most of the specific objectives listed in Section 1.4. The use of the mobile device application designed for reporting predation is described in Chapter 5, while the use of the mobile device application designed for reporting predator control is described in Chapter 6. In conclusion, Chapter 7 describes the usefulness, role and position of such a tool in coordinated predation management by providing a means to collect real-time field data on a large scale.

2 A perspective on coordinated predation management in South Africa

In the past, official support structures were responsible for many of the functions associated with predation management. This responsibility rested primarily with the provincial departments of nature conservation or similarly named equivalent departments (De Waal, 2020). Currently, many structures exist through which livestock farmers and wildlife ranchers may receive support in aspects of the management of their enterprises. However, concerning predation management, coordination is grossly lacking. The purpose of this chapter is to put the work done in this thesis in context.

2.1 Official support structures for livestock farmers and wildlife ranchers experiencing predation

An essential first step in renewed efforts at establishing a system of coordinated management in South Africa seems to investigate the factors which contributed to the successes and weaknesses of the official animal damage control programmes that ran in the past. Of particular importance is identifying the causes of its demise.

It was challenging to retrieve information from the systems of predation management that were in effect in each of the provinces pre-1994. With the assistance of officials from four of the present-day provincial conservation authorities (Eastern Cape Department of Economic Development, Environmental Affairs & Tourism; Free State Department of Economic, Small Business Development, Tourism & Environmental Affairs; Northern Cape Department of Environment & Nature Conservation; and CapeNature in the Western Cape Province), some documents from these systems were located and archived. In addition, documentation regarding efforts post-1994 to revive coordinated predation management in South Africa was sourced.

Valuable information was extracted from these documents and used to compile a document elucidating the historical course of predation management in South Africa (De Waal, 2020) and identify areas where current efforts at coordinated predation

management should focus. Learning from the lessons contained in the historical documents is vital for implementing effective predation management.

2.1.1 Coordinated predation management – pre-1994

Once it became evident that the bounty system had failed and that predation management should be based on scientific methods, South Africa started implementing a system based on methods used in the USA and adapted for South African conditions (Anonymous, 1961; Vorster, 1978/1979). The US Fish and Wildlife Services proved that such a system could only be successfully enforced by an authoritative organisation (Anonymous, 1961). In South Africa, this role was then adopted by each of the four erstwhile provincial governments during the late 1950s to early 1990s (Bergman *et al.*, 2013). Documentation from the Natal, Orange Free State and Transvaal provinces were scant and not readily available. Therefore, summarised below, the management of damage-causing wildlife in the Cape Province provides an example of the programmes operating in each of the other respective provinces. However, the level of official predation management support varied in each of these provinces (De Waal, 2020).

In 1958 the Cape Department of Nature Conservation proceeded and established a Division Problem Animal Control (De Waal, 2020). Basic functions of this division included: (i) supervising hunt clubs, (ii) research on damage-causing animals, (iii) training and extension services, (iv) breeding and training hounds for control of damage-causing animals, and (v) investigating the efficacy of particular methods for the control of damage-causing animals (Vorster, 1978/1979). Actions were coordinated on district and provincial levels.

2.1.1.1 Coordinated action

An extended sequence of milestones regarding predation management in the four erstwhile provinces of South Africa was provided by De Waal (2020).

The management of damage-causing wildlife appeared to be successful (at least during specific periods and in particular areas of South Africa) at the time Government played an active role in supporting coordinated predation management (Anonymous,

1974/1975; Beinart, 1998; Kruger, 2019 unpublished data; De Waal, 2020). Success depended on coordinated efforts (with a strong focus on obligation and continuity) between organised agriculture, local government and hunt clubs. It was also evident that better and closer cooperation was gained from hunt clubs in the respective divisional councils of the Cape Province with the development of more efficient methods of problem animal control (Anonymous, 1969/1970; 1975/1976). In terms of legislation, for example, a basic policy statement and procedure for the control of damage-causing leopard led to improved cooperation from farmers experiencing livestock losses due to leopard.

In the Cape Province, hunt clubs mainly made use of packs of trained hounds for the control of damage-causing animals. Official supervision of hunt clubs included quarterly inspections to make sure that the hounds and the facilities in which they were kept were in good condition, and that hunters' performance was satisfactory. Hunt clubs were required to submit their monthly hunt reports to regional offices. Hunters' performance was assessed from the data contained in these hunt reports to ensure that the payment of subsidies was justified (Kruger, 2019 unpublished data).

According to De Waal (2020), "*The Cape Province paid subsidies for hunters of recognised private hunt clubs and also the maintenance of packs of hunt hounds; additionally, undisclosed amounts were paid for the salaries of staff and to maintain three predation management centres, the largest being Vrolijkheid near Robertson and the two smaller facilities at Adelaide and Hartswater. The Orange Free State Province paid considerable amounts to subsidise the major part of the activities of Oranjejag, the only statutory predator control association in the Province; state funds were also used to improve and maintain Bathurst, the only permanent facility and main centre of Oranjejag's operations. The Natal Province paid undisclosed amounts to subsidise private predator hunt clubs as well as paying bounties for predators killed. The Transvaal Province paid fixed amounts annually to subsidise a single private problem animal control association. Much of the information presented here is not readily available in the public domain. It must be noted that the numbers of animals reportedly killed are much less than those actually killed in South Africa because unknown numbers of animals have not been reported; this applies both to the predation losses and the predators killed.*"

2.1.1.2 Training and extension

Training courses were presented to hunters employed by hunt clubs, farmers, farmworkers and nature conservation officials (Anonymous, 1975/1976). The courses focused on applying predator control techniques as selectively as possible to limit the killing of non-target animals, while also emphasising the collection of data for determining damage caused by wild animals (particularly predators) and other research (Anonymous, 1979/1980). Later courses included damage assessment, post-mortem examinations and the proper approach to animal damage control. Resources such as casts of animal tracks, scat and typical examples of prey caught by predators were used to ensure correct identification of damage-causing animals (Anonymous, 1977/1978).

Candidates completing the course received a certificate of competence, authorising them to use control methods such as the coyote getter, and in the case of extended courses, using hounds for problem animal control. Lectures and presentations were given at farmers' associations, schools, agricultural colleges and youth organisations.

Field stations received many visitors (Anonymous, 1980/1981), who were educated in the activities performed at the facilities. Extension services further included the distribution of information on the management of damage-causing animals in the form of pamphlets (Vorster, 1978/1979). By the 1980s, the Cape Department of Nature Conservation and Museum Services had compiled a problem animal control manual containing photographs, while fact sheets were also available with descriptions of control methods and identification of damage-causing animals.

2.1.1.3 Using existing information to inform mitigation strategies

According to a report by the Cape Department of Nature Conservation and Museum Services (Anonymous, 1985/1986), the department considered it its responsibility to ensure that the control of damage-causing animals is executed in the most effective ways across its range. Due to some divisional council's methods appearing to be more effective than others', the department deemed it necessary to examine effective problem animal control on a local level comprehensively and adequately. However,

this is the last annual report in this series available to the author; hence it is uncertain whether these examinations were ever launched.

2.1.1.4 Integration with a broader programme of human-wildlife conflict management

Much progress was made, and valuable lessons were learnt during the time in which the Cape Department of Nature Conservation supported officials in undertaking study tours to the USA (Anonymous, 1961) and the United Kingdom to gain insights on control of damage-causing animals there (De Waal, 2020). The knowledge and experience thus acquired were then adapted and implemented to suit the South African context.

2.1.2 The demise of coordinated predation management in South Africa

These systems of coordinated human-wildlife conflict were, however, abandoned during the early 1990s, for various reasons. It became evident that, besides for the geopolitical changes in government support structures, other factors that may have played a role in the disbandment of these systems in South Africa (Anonymous, 1980/1981; 1981/1982; 1984/1985; 1985/1986; Beinart, 1998; Bergman *et al*., 2013; Kruger, 2019 unpublished data; De Waal, 2020) included:

- financial constraints;
- reduced cooperation between the various stakeholders involved – there is evidence of reduced participation by farmers, or farmers failing to abide by the rules of hunt clubs;
- changing hunt club membership by farmers from compulsory to voluntary;
- some farmers not paying membership fees;
- a decrease in attendance of training courses by farmers and a decrease in sales of trained hounds;
- shortage of experienced staff – failure to fill vacant positions (problem animal hunters) and thus the inability of hunt clubs to perform satisfactorily and provide in the needs of farmers;
- hunters not being able to provide services over large areas;
- unsatisfactory submission of reports by some hunt clubs;
- an out-of-date subsidy system;

- increased pressure from environmental and animal rights activists against lethal control of predators; and
- a growing distrust between farmers and the conservation authorities.

According to farmers surveyed during the last years of the coordinated systems (Lawson, 1989), the main reason for the disbandment of subsidised hunt clubs was that the predator problem disappeared. Other reasons given by farmers included organisational problems, no neighbour support, high financial costs, lack of hounds, the system being ineffective and a lack of hunters.

Subsidised hunt clubs were phased out, dedicated research facilities were shut down, and the responsibility of managing damage-causing animals shifted towards private landowners (Du Plessis, 2013; Bergman *et al*., 2013; De Waal, 2020).

However, due to predation still being perceived as a major problem, serious efforts were starting to be made in terms of revising the approach to predation management in South Africa. These efforts culminated in the formulation and adoption on 18 November 1992 of the National Policy and Strategy for Problem Animal Control in South Africa (De Waal, 2020) and the Problem Animal Control Forum held at Golden Gate Highlands National Park in the eastern Orange Free State Province in May 1993 (De Waal, 2020). This forum brought together stakeholders and role-players, namely: the National Wool Growers' Association of South Africa (NWGA), the Red Meat Producers' Organisation (RPO), nature conservation authorities and administrations of the Cape, Orange Free State, Transvaal and Natal Provinces, prominent nature conservation officials, representatives of animal damage control organisations, Regional Services Councils, livestock farmers and specialist predator hunters (De Waal, 2020). Key areas (communication, control, training and research and development) for advancing strategies as well as specific objectives were identified, and strategies were formulated by the National Problem Animal Policy Committee (NPAPC).

2.1.3 Efforts at coordinated predation management – post-1994

In anticipation of the pending new geopolitical dispensation in South Africa, an English version of the National Policy and Strategy for Problem Animal Control in South Africa was issued on 17 February 1994 by the NPAPC (De Waal, 2020). However, with the implementation of these new geopolitical arrangements from April 1994, state priorities were shifted, and predation management may have been moved to the background (De Waal, 2009).

The two groupings with direct effects on livestock farmers and wildlife ranchers, namely the departments of agriculture and environmental affairs, each now had a national department and nine provincial departments. As a result of this reorganisation and the redeployment of both national and provincial government officials, the recommendations of the Problem Animal Control Forum were not implemented.

Considerable efforts have, however, been made since 1994 by livestock farmers, wildlife ranchers and other role players to gain support from Government regarding predation management once more (De Waal, 2020). These efforts have led, among other things, to the formulation of the Environmental Management Biodiversity Act, 2004: Act no. 10 of 2004 and the drafting of the “Norms and Standards for the Management of Damage-Causing animals in South Africa” by the Department of Environmental Affairs and Tourism (DEAT) during 2009.

With the launching of the Canis-Caracal Programme (CCP) in 2004, efforts were accelerated since 2005 to create awareness of the urgency and opportunities of the predation scene in South Africa and lobby widely for a system of coordinated predation management (De Waal, 2009; 2017a; 2020). The CCP lobbied on various platforms and at different levels to stakeholder groups, including:

- scientists, through project proposals and applications, and conference contributions, both nationally and internationally;
- nature conservation/wildlife/biodiversity bodies, through meetings, workshops, etc.;
- retail chains (e.g., Woolworths) creating awareness among consumers; and

- farmers (individuals, associations and animal damage control specialists representing their industries).

The Livestock and Wildlife Working Group on Damage Causing Animals, which later became known as the Predation Management Forum (PMF), was founded in 2009 in an attempt by livestock farmers and wildlife ranchers to seek solutions for predation management in South Africa (De Waal, 2020). The primary role players in the PMF are the National Wool Growers' Association (NWGA), the Red Meat Producers Organisation (RPO), the South African Mohair Growers' Association (SAMGA) and Wildlife Ranching South Africa (WRSA) at national and provincial levels (De Waal, 2009; 2012). Interested parties, such as scientists and academics, also attend PMF meetings by invitation (Du Plessis, 2013; De Waal, 2020). These efforts culminated in a visit to the USA by a 4-person delegation, from 17-31 May 2010 (De Waal, 2020). First-hand interaction with professionals of the Wildlife Services (WS), United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), highlighted the comparatively fragmented and uncoordinated approach to predation management still practised in South Africa. Such a lack of coordination is a significant shortcoming which hampers meaningful mitigation of the negative impact of predation.

Despite much progress having been made between 2009 and 2012, however, the momentum has been waning in the absence of a unifying system of coordinated predation management in South Africa (De Waal, 2009; 2012).

2.1.4 Current support from Government

Until recently, predation management was still mainly the responsibility of livestock farmers and wildlife ranchers themselves, with government support coming mainly from the Department of Environmental Affairs. Currently known as the Department of Environment, Forestry and Fisheries (DEFF), the role of this government department still broadly encompasses providing support to affected parties, although it is much less pronounced. According to Strydom & Strydom (1996), the services provided by Government in terms of predation management support should be aimed at activities

that affect the community as a whole or activities that require specific expertise not available in the private sector; these may include:

- Providing financial aid to animal damage control organisations in areas where it is needed;
- Initiating research projects relating to damage-causing animals;
- Participating in extension programmes aimed at reducing livestock losses with the aid of more effective and ecologically and ethically acceptable methods;
- Participating in the training of animal damage control specialists and farmers where the private sector is unable to fulfil this role completely;
- Providing devices and equipment to animal damage control organisations and individual farmers where this cannot be done in the private sector or where otherwise preferable that the authority provide it; and
- Regulating animal damage control practices and the conservation of species and ecosystems.

The extent to which these support services are currently provided differs markedly between the nine provinces. One of the factors complicating the role of Government is the fact that the responsibility of managing damage-causing animals lies within different structures in some of the provinces. The Gauteng Province, for example, does not have a separate conservation authority; topics of environmental concern fall under the scope of the Gauteng Department of Agriculture and Rural Development (GDARD). The Eastern Cape and KwaZulu-Natal provinces, on the other hand, each have an additional department dealing with different aspects of environmental concern. The Eastern Cape has the Department of Economic Development, Environmental Affairs and Tourism (DEDEAT) and the Eastern Cape Parks and Tourism Agency (ECPTA), while KwaZulu-Natal has the Department of Economic Development, Tourism and Environmental Affairs (EDTA) and Ezemvelo KZN Wildlife. In some instances, particularly regarding managing damage-causing animals which are threatened or protected species, there is no clear divide between the responsibilities of each of these governmental bodies.

Currently, the Western Cape (and its parastatal CapeNature) is the province with the most detailed, extensive and well-practised management framework for the

management of damage-causing animals. In 2013, a Cooperative Agreement was signed by the Predator Management Forum of the Western Cape and the Western Cape Nature Conservation Board trading as CapeNature (2013). The Agreement has promoted cooperation between CapeNature, farmers, specialist predator hunters and NGOs. Although the Agreement requires that records be kept of predation incidents and predation management practices, certain aspects, such as research and monitoring, are still lacking to incorporate into an adaptive approach to predation management.

Currently, involvement in predation management by the national Department of Agriculture, Rural Development and Land Reform (DARDLR) is largely limited to the funding of some research. However, efforts have been made in recent years to address predation management issues by hosting information days and occasional workshops and involvement in individual projects.

Information days hosted by DARDLR included the Predation Management Information day in Beaufort West in 2011 and the Technology Transfer on Predation Management at the Glen Agricultural Institute in 2012 (De Waal, 2020). Although both events were well-attended and much positive feedback was received from attendees, they seem to have been once-off events and did not constitute a continuous, coordinated process with active involvement by DARDLR on farm level.

Projects in which DARDLR are currently involved include the Shepherding Back Biodiversity Project and the Koup Fencing Project in the Western Cape Province. Some provincial departments also host workshops addressing the management of damage-causing animals as part of sustainable agriculture (Darryl Johnson, 2018 personal communication). However, coordination of efforts between the respective provincial departments, as well as between the provincial and national departments, is lacking.

To address this issue, DARDLR is working towards getting people/structures in place provincially and inter-provincially to actively engage in coordinated efforts (Victor Musetha, 2018 personal communication). The PMC has engaged in discussions with DARDLR in support of this process to drive discussions regarding operation Phakisa

(De Waal, 2020). Operation Phakisa is a government initiative to address issues highlighted in the National Development Plan 2030 (South African Government, 2019) by translating detailed plans into tangible results through dedicated delivery and collaboration. The PMC also liaises with the DARDLR national representatives on the development of government structures that coordinate with regard to predation management on a provincial level, as well as coordinated management between the respective provinces and the national department. In addition, the PMC has assisted DARDLR on provincial level in terms of distributing relevant information (as contained in databases described in Section 2.2) to offices in need of assistance with regard to researching predation management.

2.1.4.1 Coordinated action

Within the Department of Environment, Forestry and Fisheries (DEFF) there has until recently been a lack of communication and coordination of predation management, both between provinces and between the national and the respective provincial departments (De Waal, 2020). This lack of structure poses major challenges, not only in efforts to coordinate predation management but also with respect to other issues of conservation and agricultural importance.

Subsidised hunt clubs do not exist anymore. The involvement of conservation authorities with private hunting associations and individual predator control specialists and farmers is currently mostly limited to support in terms of assistance with the issuing of permits, assistance with the management of damage-causing animals (particularly those listed as threatened or protected species) and advising on matters relating to the control of damage-causing animals. However, this support is conducted differently in the respective provinces (De Waal, 2020).

As with all other aspects of predation management in South Africa, research and development are fragmented and uncoordinated. Studies have been conducted on similar topics, in more or less the same areas, and similar timeframe. In many cases, scientists are not aware of other scientists or research projects. Combining such efforts and finances into more extensive programmes may be more effective in achieving the common goal of reducing the overall impact of predation. Some of the completed and or prospective studies on aspects relating to predation management

can be found on the Nexus database. However, this database contains only studies funded by the National Research Foundation (NRF). An important step in the right direction would be to ensure that all (completed as well as current and prospective) studies relating to predation management are available for reference on such a database, and accessible to all involved in research.

Research facilities such as at Vrolijkheid (Anonymous, 1961), built specifically for research on damage-causing animals and for developing control methods, facilitated research conducted mainly by officials employed as animal damage control specialists. Since the shut-down of these facilities with the phasing out of subsidised hunt clubs (Lensing, 1993), research conducted directly under the Department of Environment, Forestry and Fisheries (DEFF) has been limited.

Vast but unknown amounts of money are spent on funding for research. Yet, there is little evidence that the outcomes of such studies are used to inform future efforts of predation management. There is also little evidence that recommendations stemming from these studies are implemented, and that such actions are monitored to verify sustainability of said recommendations or practicality and long-term efficiency in reducing predation.

Obtaining legislation currently in effect, either nationally or on a provincial level, from government websites is difficult. During this study, most of these items were sourced from websites of non-governmental organisations. Therefore, unless a producer has already established contact with the relevant government official in that province who deals with predation management issues, sourcing this type of information from the government department itself is challenging.

The deficiency in coordinated action is also found in the private sector, as highlighted in Chapter 4 as well as dealings of the PMiC with private individuals since early 2017.

2.1.4.2 Training and extension

Training courses on predation management are currently mainly presented by private predator control specialists. A process of getting some of these courses and training providers accreditation from AgriSeta has been introduced in efforts to ensure that

effective, responsible predation management is taught and to eliminate the process whereby some trainees copy course materials to conduct training themselves for financial gain. Government involvement in training and extension is limited to visits by provincial conservation authorities to farming communities, institutions such as agricultural schools (Lourens Goosen, 2018 personal communication) and workshops and information days as described previously.

2.1.4.3 Using existing information to inform mitigation strategies

Despite attempts by the PMiC to collect current information from livestock farmers and wildlife ranchers, response has been poor. As a consequence, no real progress has been made since the start of the PMiC in terms of informing mitigation strategies. However, the tool developed in this study (see Chapters 5 and 6), in conjunction with improved cooperation between stakeholder groups, has the potential to address the problem.

2.1.4.4 Integration with a broader programme of human-wildlife conflict management

Valuable information was obtained during the 2010 visit to the USA by a group of South African delegates (Section 2.1.2), and dedicated efforts were made to relay the information to role-players and drive the practical implementation of the knowledge gained. Feedback presented to the PMF Steering Committee (De Waal, 2020) emphasised that a system of coordinated predation management relies on:

- *Concrete research support involving various institutions;*
- *Research conducted on farms designated for this purpose;*
- *Continual improvement of equipment to improve selectivity and humaneness*
- *A strong focus on the emotions of the public, a point that is lacking in South Africa; and*
- *Wildlife being a priority of the public* (also see Bodenchuk *et al.,* 2013).

Although progress has been made concerning the first three points listed above, there is still notable fragmentation of efforts. More emphasis has been placed on the need for incorporating social factors involved in human-predator conflicts on a local scale (Du Plessis, 2013; Madden & McQuinn, 2014). However, on a larger scale, South

Africa grossly lacks the focus on social factors (discord within as well as between various stakeholder groups).

Therefore, in working towards addressing issues such as insufficient backing from Government and the absence of the necessary focus on the human dimensions of the prevailing situation in South Africa, the PMiC has joined the information-sharing network of the Centre for Conservation Peacebuilding (CPeace). CPeace (formerly known as the Human-Wildlife Conflict Collaboration, or HWCC), acts as a global network that supports greater collaboration on human-wildlife conflict across disciplines, sites and policy areas by sharing information and expertise in addressing human-wildlife conflict. The international forum HWCC was established in November 2006 to act as a global network that supports greater collaboration on human-wildlife conflict across disciplines, sites and policy areas by sharing information and expertise in addressing human-wildlife conflict. Developing and improving best practices and policies for human-wildlife conflict management can be achieved through such a partnership that facilitates collaborative learning, innovation and scientific analysis.

Several other organisations and institutions internationally have reported improved collaboration and communication between different stakeholders involved in human-predator conflict since participating in capacity building workshops hosted by this body, and collaborating on a large scale (Manfredo, 2015). Improved collaboration, in turn, has led to better human-wildlife conflict strategies and improved political and legal support for human-predator conflict management programmes.

2.1.5 Support structures abroad

Countries make use of different systems of human-wildlife conflict mitigation, as determined by the nature of the conflict, ecological and socio-economic and political factors. Of particular interest here, is the example of the USA with its long history of similar problems dealing with coyote (*Canis latrans*) and bobcat (*Lynx rufus*).

The USA Congress established a federal wildlife damage management programme in 1885 to mitigate human-wildlife conflicts (Bodenchuk *et al*., 2013). The role of USA government (US Department of Agriculture, Animal and Plant Health Inspection

Service, USDA-APHIS) in predation management is to protect the environment while assuring the appropriate protection of private property from wildlife damage, as well as to provide oversight of the predation management programme (Bodenchuk *et al*., 2013). Human-wildlife conflict mitigation is achieved through this programme by providing federal leadership, policy and funding. State agencies provide support in the form of consultation services, animal damage control at landowner's request, and subsidies for equipment such as fencing and dispersal devices (Yoder, 2000). Some State agencies and or non-governmental organisations provide compensation for damage caused by wildlife, as determined by the type of property and specific wildlife species involved (Yoder, 2000).

Today the USDA-APHIS administers the integrated wildlife damage management programme under the title of Wildlife Services (WS). The programme includes non-lethal and lethal management, and research into human-wildlife conflicts and impacts and the ecology of wildlife species causing damage (Miller, 2007; Bodenchuk *et al*., 2013). Educational outreach and technical assistance are also responsibilities included in the programme. Before testing predation management tools in the field, they are tested with captive coyotes at facilities dedicated to research on human-wildlife conflicts (Bodenchuk *et al*., 2013). The importance of investing in long-term research was recognised to ensure continued success of the programme (Accord, 1999). This robust research focus was implemented and has contributed to the development of improved strategies for managing damage-causing animals.

The type of information available through research aid in policy formation. In turn, data is collected through a Management Information System (MIS) and with the aid of the policies put in place by these systems. Such management of information gives rise to more research on the topic and provides a basis to evaluate the programme. Frequent evaluations of the Animal Damage Control Program in the USA enable wildlife managers to follow historical changes in approach and perceptions and provide stakeholders with reports and summaries of activities and accomplishments (Fall, 1990; Lowney *et al*., 1997).

The National Wildlife Services Advisory Committee, previously known as the National Animal Damage Control Advisory Committee (Accord, 1999), forms an integral part of

this programme. The Committee is composed of representatives from the agriculture industry, conservation and environmental groups, land use groups, and wildlife agencies. Recommendations by the Committee to the Secretary of Agriculture inform policies and issues regarding wildlife damage control (Accord, 1999).

The federal Wildlife Services (WS) programme was established with the understanding that individual states also had an interest in predation management, and therefore encouraged the program to cooperate with states, local jurisdictions, individuals, public and private agencies, organisations and institutions (Bodenchuk *et al*., 2013). For example, in Texas, cooperative relationships are established by a three-party Memorandum of Understanding, which provides the overall framework for cooperative programs. Cooperation varies according to the level of state and private funding dedicated to similar purposes and the vulnerability of livestock in specific areas (Bodenchuk *et al*., 2013).

In Canada, property owners are responsible for providing the manpower required to prevent damage caused by wildlife. Government provides financial assistance for materials required to prevent damage on private and leased land, particularly where wildlife species protected by law are causing the damage, and where a significant source of income is involved (Dorrance, 1983).

Predation management in Australia is also government-assisted. The role of Government entails conducting research, funding of essential predation management activities and cooperation with states/territories in developing conflict mitigation strategies (Du Plessis *et al.*, 2018). The system includes a Government-maintained Dingo Barrier Fence enclosing the major sheep producing regions to prevent the ingress of canids. The system used in Australia is unique, however, in that all wild dogs (including dingoes) and foxes are introduced species and are regarded and managed as pests outside of conservation areas (Allen & Fleming, 2004).

Recently, the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Habitat Directive of the European Union began exerting pressure on governments of European countries to actively mitigate human-predator conflicts (Du Plessis *et al.*, 2018). Norway, for example, makes use of a

“National Large Carnivore Monitoring Program” run by the Norwegian Institute for Nature Research, while the Norwegian Office for Environmental Affairs also collects data on predator control (Herfindal *et al.*, 2005).

In countries such as the USA (Yoder, 2000), Canada (Dorrance, 1983), Mexico (Zarco-González *et al.,* 2013), Bhutan (Sangay & Vernes, 2008), India (Miller *et al.*, 2015) and Norway (Herfindal *et al.*, 2005), where commercial livestock farmers graze livestock on state land, compensation schemes are implemented to reimburse farmers for losses due to predation.

In Namibia, integrating human-predator conflict management strategies on an international scale enabled conservation professionals to develop regional conservation strategies, which resulted in national programmes developed under a government structure (Marker & Boast, 2015). It enabled capacity building for scientists and extension officers to provide training to farmers, and thus stimulated awareness building and government involvement. This approach also promoted the spread of the conservancy programme to other African countries, providing a basis for the development of large-scale, transboundary land management plans. Research serves as foundation for the conservation and education programmes under this initiative (Marker & Boast, 2015).

In Botswana, compensation schemes are used to mitigate human-predator conflicts along the borders of nature reserves (Schiess-Meier *et al.*, 2007; Rutina *et al*., 2017) and requires verification by state officials of livestock killed by predators. In South Africa, livestock grazed on state land are mostly subsistence farmers whose livestock are kept on communal land, but no coordinated system is in place to mitigate human-predator conflicts.

2.2 The role of a Management Information System (MIS) in coordinated action

Institutional memory forms the backbone of any management plan. Since coordinated predation management in South Africa was abolished in the 1990s, much of the associated institutional memory was also lost. In efforts to rebuild and maintain

institutional memory, a Management Information System (MIS) consisting of various databases and archives was created by the Predation Management information Centre (PMiC) at the University of the Free State (De Waal, 2017a; 2020). The broad functions of an MIS are to describe the status quo of a particular subject, define problems in order to know how to deal with or avoid future problems, and to prescribe modes of action to make progress in that particular field (Harsh, 2005). An MIS should also provide a network structure to enable coordinated action.

2.2.1 Documents, databases and equipment

The databases created to list the stakeholders and role-players directly affected by, or involved in, predation management serve as basis for the networking and information-sharing platform.

The procedure followed to acquire the contact details of relevant officials in the respective government departments (Section 2.1), highlighted the fact that farmers who are not members of an intricate network of producers' organisations or farmers' associations may not have easy access to such information. None of the websites of the national or provincial departments of agriculture and environmental affairs contained information relating to the management of damage-causing animals (besides for permit application forms). The websites of at least three provincial environmental affairs departments were outdated. Information on government officials who may be able to assist in predation management was therefore not available on these platforms.

The fact that the responsibility of predation management does not necessarily rest with a particular province's department of environmental affairs (Section 2.1.4) also greatly complicates the search for the contact details of an official to assist farmers experiencing livestock predation. In two of the provinces, efforts to contact government official(s) knowledgeable in the field of predation management were unsuccessful and further complicated the acquisition of documentation regarding legal aspects of predation management in those provinces. These were the same two provincial conservation authorities that have repeatedly shown a lack of cooperation regarding

predation management in recent years (De Waal, 2020), for various reasons (Thorn *et al*., 2013).

In the process of verifying contact details of livestock and wildlife producers' organisations, academic and research institutions and predator specialists, the foundation was laid for communication between the PMiC and some individual stakeholders and role-players. However, in various attempts to communicate with some stakeholder groups and individuals, it became evident that there were factors hampering successful communication, and that strengthening network ties is key to improving communication.

Legislation regarding the management of damage-causing animals is predominantly the responsibility of the national and provincial conservation authorities. Relevant acts, regulations and policies regarding predation management were, however, not easily obtained from the relevant authorities' websites. The contact details of officials dealing in animal damage management (obtained through the extended network of the PMF) were used to source the documents from each of the provincial conservation authorities. Furthermore, additional documents, which were not available online or by enquiring about it at each provincial head office, were also sourced by contacting these specialists. Government officials who were involved in predation management during the time of coordinated systems of predation management in South Africa, and still work for the provincial conservation authority in that capacity, have been of invaluable help in retrieving such information.

In attempts to address human-wildlife conflict, the Department of Environmental Affairs and Tourism (DEAT) issued a draft *National Environmental Management:* Biodiversity *Act, 2004 (Act 10 of 2004): Human-Wildlife Conflict Management ("Damage-Causing Wild Animals") in South Africa* Regulations (De Waal, 2020). Although legislation governing the management of damage-causing animal species in some provinces are outdated, such outdated provincial legislation can only be updated and finalised once the National Norms & Standards for the Management of Damage-Causing Animals in South Africa under this act have been promulgated (De Waal, 2020).

Since 2011, DEAT (now known as the Department of Environment, Forestry and Fisheries, or DEFF) has intensified efforts to move away from the “1 + 9 system” (a national department with its nine provincial departments), where the regulation of management of damage-causing animals differed in many of the provinces. Although much progress has been made, management of damage-causing animals is still subject to the “1 + 9” scenario. An MIS will be useful to coordinate the management of damage-causing animals within as well as between the respective provinces, particularly specific issues referred to in Section 2.1.4.

The fragmented way in which research on human-predator conflict in South Africa has been conducted to date has resulted in gaps in scientific knowledge. Recently, there has been an increase in predation management-related research, yet there is still little coordination of research efforts, and virtually nothing filters through to the farmers. Therefore, a separate database is being developed by the PMC, containing detail on all research conducted on human-predator conflict in southern Africa. This database may serve to inform future research efforts to prevent duplication of work where there is overlap in areas, timeframe or topic. Furthermore, incorporating the efforts of official structures such as that provided by CapeNature (Section 2.1.4) may ensure that research forms part of an adaptive management framework, thereby promoting cooperation between the relevant stakeholder groupings.

During the development of this database, it was realised that there is currently no structure to review the topics and findings of completed research that has been conducted. Hence, recommendations from studies are not evaluated by a single body to ensure that recommendations are implemented. The database currently being developed may help overcome these challenges.

The literature currently contained in the PMiC archives includes publications on predation management systems in other countries. This collection serves to build a comprehensive knowledge base on predation management programmes/systems used in other countries, and how certain concepts can be applied or adapted to the South African setting. Other literature sourced includes research conducted regarding predation management in recent years. Although the importance of coordinated research has been stressed by Du Plessis (2013), it is evident from the most recent

peer-reviewed publications that research efforts are still fragmented and uncoordinated (Balfour & Kerley, 2018).

Information on available devices and equipment for the management of damage-causing predators was sourced, and some devices and equipment were obtained as examples to incorporate as visual aids into training courses and information sessions to be facilitated by the PMiC.

2.2.2 Integration into a coordinated predation management programme

Due to the complicated nature of wildlife management, decision-makers in the early days of predation management in South Africa recognised the importance of creating good relationships with and establishing cooperation of the public, farmers' associations and divisional councils. Therefore, it was realised that such issues would have to be explained to the public in person (Anonymous, 1961). Conservation officials attended meetings of farmers' associations and Divisional Councils to provide technical support and advice, which led to a better understanding of the workings of the Problem Animal Control Station at Vrolijkheid (Cape Province) and promoted better relationships with the farming community (Anonymous, 1975/1976).

In efforts to resume many of the functions historically performed by the Problem Animal Control Divisions of the respective Nature Conservation departments, the PMC has undertaken to facilitate training and extension activities. Functions include training and extension performed by accredited predation management instructors among farming communities, animal damage control operators and agricultural extension officers, the production and distribution of information leaflets or fact sheets, and the collection of photographic material, predation management devices and equipment to serve as training materials. The materials described in section 3.1 were used to produce or supplement many of the training materials. However, to facilitate training courses performed by predation management instructors, AgriSeta accreditation needs to be acquired, and the initiation of this process was time-consuming. This onerous process, together with the lack of communication and differences in personal convictions among individuals and some stakeholder groups, have slowed down progress with regard to training and extension services considerably.

Generally, there is a relatively large degree of engagement and cooperation between several farmers and ranchers and predation management specialists individually. However, there is also a high level of distrust and conflict between, as well as within, some stakeholder groups. Improving and maintaining stakeholder engagement is dependent on one-on-one relationships (Michael Bodenchuk, 2018 personal communication) between persons affected by predation, those providing assistance in terms of predation management, and those responsible for coordinating predation management activities (whether it be physical control of predators, training and extension, or information management).

Data regarding predation management exist in many different forms and different places but are the least freely available and most difficult to obtain, for various reasons. Such information is crucial in supplementing the knowledge already available in the scientific domain to improve predation management efforts. Obtaining existing unpublished information on predation management is challenging. Among this information are reports from the previously active systems of predation management. These reports contain valuable information on how these systems worked and the challenges they faced at that time, as discussed in Sections 3.1 and 3.2. Currently, however, the most critical information needed is information on the current situation regarding predation management in South Africa. This information has been the most difficult to obtain.

To address this lack of data, efforts were initiated in 2011 to collect detailed predation management data on farm-level as a follow-up to the study by Van Niekerk (2010), which estimated the large-scale damage of predators on the small livestock industry. Results of these efforts are described in Chapter 4. The development of a tool to incorporate such data into an MIS is described in Chapter 5.

The databases and archives contained in the MIS have already played an important role in initiating and supporting projects by providing input and information. Further development of the networking function of the PMiC is necessary to ensure that these databases are put to full use.

3. Material and Methods

Keeping track of past and present developments is important to ensure effective, responsible predation management. Therefore, institutional memory regarding predation management should be maintained in an appropriate Management Information System (MIS - Michael Bodenchuk, 2010, personal communication cited by De Waal, 2020). An MIS in this context ultimately also serves to evaluate impacts on agriculture, natural resources, property, human health and safety and damage-causing predator species. Furthermore, it serves to evaluate the efficacy and efficiency of management approaches and evaluate public and government accountability.

With specific reference to a system of coordinated predation management, a well-designed MIS is needed in South Africa to enable the following:

- Information resource management;
- Information dissemination;
- Data collation and research;
- Formulating best practices in predation management;
- Management decisions based on documented predation losses, management responses and research outcomes; and
- Evaluating whether coordinated predation management succeeds in mitigating the negative impact of predation.

Therefore, an MIS was developed under the auspices of the Predation Management Centre (PMC), to serve as administrative backbone and source of institutional memory for coordinated action. This initiative was supported and funded in part by the Predation Management forum (PMF). The MIS consists of several uniquely designed databases and archives containing details on role players, legislation, publications, management methods, and other information regarding predation management.

The development of an MIS is discussed in this chapter, with particular focus on a succession (evolution) of methods used to develop a practical tool for data collection to address current knowledge gaps and the lack of coordination particularly in the field of predation management research.

3.1 Documents, databases and equipment – the Management Information System (MIS)

3.1.1 Role players involved in predation management

The database is designed to maintain information on important networks and facilitate the flow (collation and dissemination) of information. A number of stakeholders were identified:

(a) regulatory authorities and government departments, both nationally and in the nine provinces;

(b) management specialists and instructors, manufacturers or distributors of methods, devices and equipment;

(c) Predation Management Forum (PMF) and the livestock and wildlife producers' organisations; and

(d) other role-players such as academic and research institutions, and predator specialists.

The procedure followed to source the contact detail of paragraphs (a) and (b) above, was to pretend to be a livestock farmer or wildlife rancher experiencing predation challenges, with no access to relevant information through such conventional organisational structures as producers' organisations or farmers' associations. Web searches were performed to source the information. Where contact details were not available from other online sources, it was obtained from the PMF. The information was then verified by telephone and e-mail and, where necessary, appropriately updated. The details of authors, supervisors, promotors, co-supervisors and co-promotors of research projects conducted at tertiary institutions on predation on livestock and wildlife, human-wildlife conflict management and predator biology over the past 10 years were added in paragraph (d) of this database. The latter information was obtained from peer-reviewed publications, dissertations and theses (see Section 3.1.3).

3.1.2 Related legislation

The database contains relevant acts, regulations and policies regarding predation management. The information is needed to identify gaps in the regulatory framework, which may be addressed to achieve coordinated predation management. This

information was sourced via the internet to scrutinise the ease of access for those who do not belong to networks or organisational structures (such as producers' organisations or farmers' associations) through which such information is usually available. Firstly, the respective national or government departments' websites were searched for the relevant documentation. Where it was not available on such a website, a general web search was conducted. The relevant information contained in section 3.1.1 above was then used to source any outstanding documentation from official sources (Section 2.1).

3.1.3 Publications

The database and archive comprise a collection of publications (hard copy and/or electronic format) on predators, predation on livestock farms and wildlife ranches, predation management and relevant associated topics, both locally and internationally. Peer-reviewed publications (sourced via avenues such as Research Gate, JSTOR and Google Scholar) and popular literature on predation management and human-wildlife conflict-related content, is continuously searched for and archived.

The purpose of this database is to form part of an information-sharing network to keep abreast of recent and relevant advances in predation management and to inform stakeholders about research conducted on those topics. A stakeholder is defined as an individual or group who may be affected by or can affect wildlife management decisions and programmes (Decker *et al.,* 2002).

Information leaflets and posters were produced with the information sourced from this collection for training and extension purposes. It also serves as an aid to initiate and support research projects, as well as to inform present-day predation management practices. Leaflets and posters will be publicly available, while resources such as peer-reviewed publications may be made available on request to particular stakeholder groupings.

An additional database was created, listing all predation related studies from southern Africa. This database contains details such as study areas, study periods, methods used, specific topics covered, findings and recommendations and may serve as the

basis to address the lack of coordination regarding relevant research in South Africa. Although the database currently only contains completed studies, the aim is to include studies in progress as well. Such a database should be accessible only to “verified” users, e.g. a scientific advisory committee or similar entity making decisions on or planning future predation management research. Additional detail such as institutions to which individual authors are affiliated and contact details of lead authors may serve to inform future research on predation management and as an aid to coordinate research to eliminate duplication, investigate collaboration possibilities and provide access to archived data.

3.1.4 Management methods, devices or equipment

The database contains information on methods and devices used in the past as well as currently available for legal, responsible predation management for training and extension purposes. Much of the information in this database draws on information collected in sections 3.1.1 and 3.1.2 above.

3.1.5 Information on predation and predator control

The database includes official documentation from past systems of predation management in South Africa (see Section 2.1). This historical information is crucial to highlight the strengths and weaknesses of past systems of predation management for future efforts to build upon. The collection of documentation also includes recent information on predation and predation management activities. The more recent predation management information available, however, does not contain the detail necessary to enable meaningful analysis and subsequent development and evaluation of management strategies. Hence, the main focus of this study was to develop methodology and a tool (Section 3.3) to address this deficit.

Individuals directly involved in predation management, namely livestock farmers, wildlife ranchers and specialist predator hunters (including government officials involved in predation management) are the most important sources of information to create institutional memory. Incorporating local knowledge and experience (McCall & Dunn, 2012; Constant *et al*., 2015) is a priority in compiling best practices and guidelines in predation management. Obtaining information on the current status of

predation management in South Africa is difficult, time-consuming and costly. Yet, such information should form an integral part of an MIS for any real progress to be made in terms of establishing a system of coordinated predation management. Appropriate technology and methods are urgently needed to collect reliable longitudinal data (repeated measurements or observations over time) on predation and predation management on farm level.

CyberTracker software was used to create a tool in the form of two mobile device applications to provide those involved in predation management a user-friendly, cost-effective means for collecting real-time data on predation losses and predator control. The tool was also created to serve as an aid for record-keeping by livestock farmers and wildlife ranchers. One application was developed for collecting data on predation losses, while a second application was developed for collecting data on the control of damage-causing animals. Combined with information obtained through questionnaires and longitudinal engagement with livestock farmers and wildlife ranchers (Section 3.3.1), the methodology may provide the detail necessary for formulating practical human-predator mitigation strategies (Thorn *et al*., 2013).

The two applications were tested using data collected from livestock farmers by means of questionnaires, as well as being tested in the field by professional predator control specialists. The development of this digital data collection tool and associated methodology for collecting current data on predation management played a crucial part in the process of developing the MIS. Although the focus of this study is mainly on this part of the MIS (namely, capturing information regarding predation and predation management), it is important to note that, to achieve coordinated predation management, this component of the MIS cannot be separated from the components described in sections 3.1.1 to 3.1.4.

3.2 Study areas

Frequent references are made to the “erstwhile four” provinces and the “current nine” provinces of South Africa; therefore, this must be put in context. In a recent baseline document on predation management in South Africa, De Waal (2020) provided “*information for the four erstwhile provinces: Cape, Orange Free State, Transvaal and*

Natal. This timeline continued for the new geopolitical dispensation which was created in South Africa on 28 April 1994 with a geographical reconfiguration in nine provinces, namely: Western Cape, Northern Cape, Eastern Cape, Free State, KwaZulu-Natal, North West, Gauteng, Mpumalanga and Limpopo." The current nine provinces of South Africa are shown in Fig. 3.1.

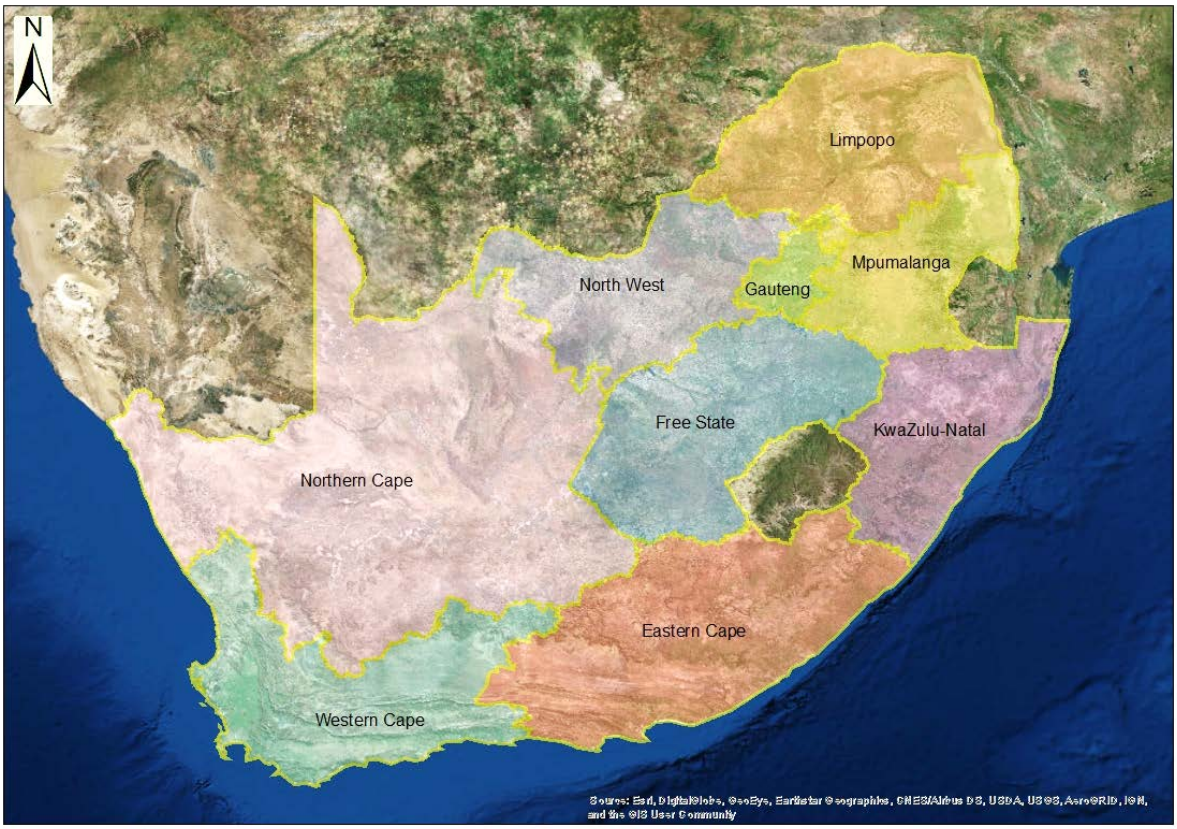

Figure 3.1 The nine provinces of South Africa; surrounding the mountain Kingdom of Lesotho, a sovereign enclave which is not part of South Africa.

The Northern Cape Province in the north-west of South Africa is geographically the largest and covers several biomes and climatically diverse regions. Farming with small livestock is one of the primary land uses of the province. According to Van Niekerk (2010), small livestock farmers in this province experience considerable losses due to predators. Therefore, it was decided to collect data from this province as being representative of an important sheep-farming area in South Africa.

Data from the telephonic survey by Van Niekerk (2010) were used to identify specific farms in the Northern Cape that have reported predation losses. Five clusters of farm areas that reported predation were identified (Areas 1 to 5, Fig. 3.2). These areas were

targeted to “zoom in” on for collecting more detailed information at farm level, namely: the date, location and livestock species predated on in each predation incident, management practices on each farm to prevent predation, as well as the date, location, predator species removed and methods used in each predator control operation. Information days and working sessions served as platform to provide feedback on the completed study by Van Niekerk (2010), introduce the follow-up study by the CCP (the present study) to each group and initiate the data collection phase of the study.

3.2.1 Data on predation losses and predator control provided by livestock farmers and wildlife ranchers

Collection of data commenced in May 2011. Meetings were scheduled with livestock farmers in Areas 1 and 4 (Fig 3.2) to explain the purpose of the study and start collecting data over a one-year period. The farmers were assured that anonymity and confidentiality of information would be maintained. They were then guided through the process of completing the questionnaire, which consisted of two parts (see section 3.3.1; Appendix 1), to ensure a measure of standardisation with regard to the completion of questionnaires by participants. The first part of the questionnaire was designed to record information on the physical characteristics of each production enterprise, as well as husbandry and predation management practices.

The farmers were provided with the second part of the questionnaire to complete and return on a monthly basis, until the end of the one-year period. This part of the questionnaire contained information on predation losses and subsequent predator control. Note that the design and specific content of the evolution in the development of the questionnaires will be presented and discussed in detail in Chapters 4 to 6 and Appendix 1.

Up to August 2011, the response by participants in Areas 1 and 4 were unsatisfactory, and the general progress stalled. Other factors (see Section 4.1) also prevented data collection in Areas 2, 3 and 5. The decision was therefore taken to extend the study area to other areas where predation was perceived to be a problem, and where tangible interest was shown by livestock producers to participate in the study.

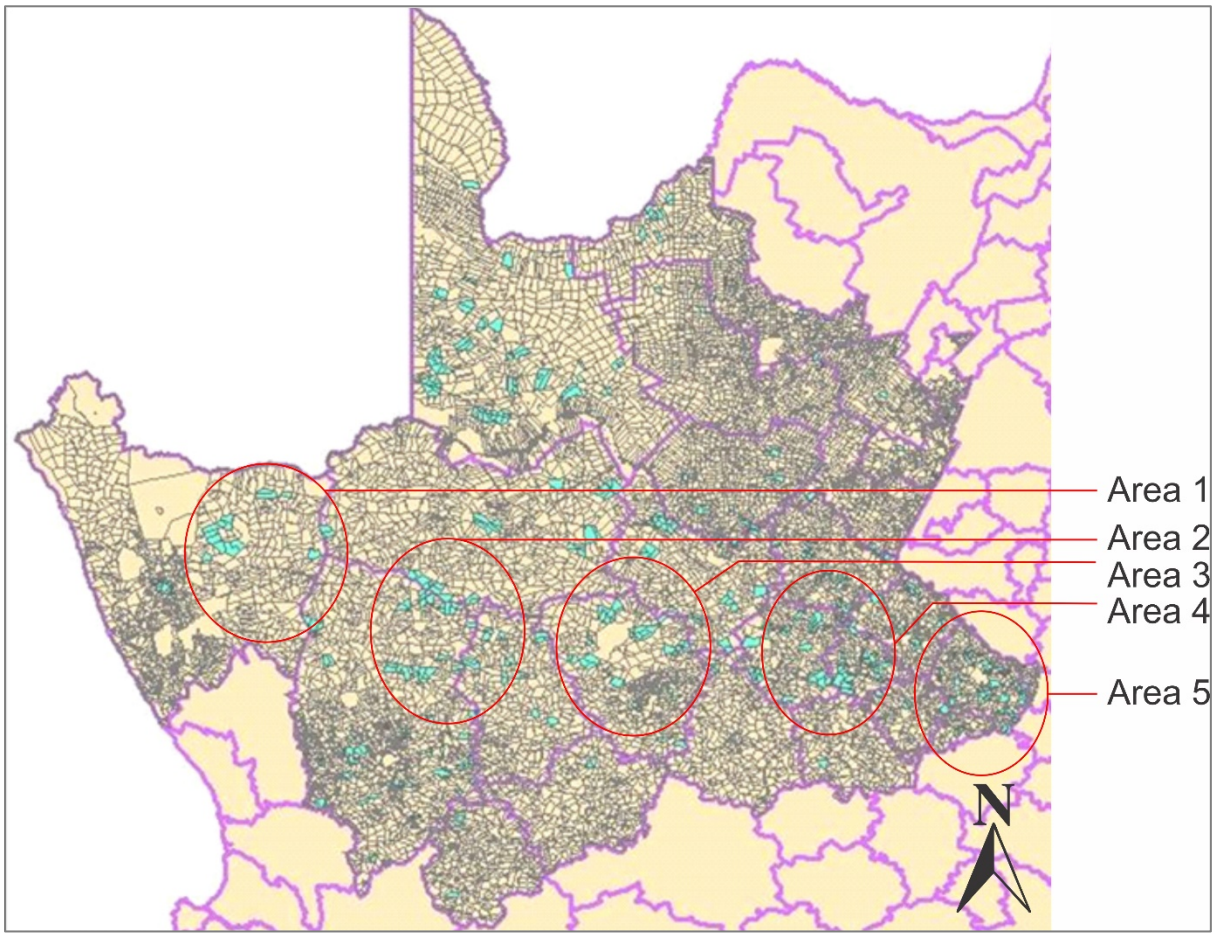

Figure 3.2 The five clusters of farms (Areas 1 to 5) in the Northern Cape Province identified for collecting detailed data on predation management.

The areas, in which data were now collected, were designated Groups A, B, C and D, according to the chronological order in which they were visited (Fig. 3.3). In addition, the size of each circle is representative of the size of the group.

A number of individuals indicated their interest in participating in the study after addressing stakeholders at four events during 2011-2012 (see Section 4.2.3) on the issue of predation and the paucity of predation management information (see Section 4.1). In March 2012, a meeting was held with a group of farmers in the Thabo Mofutsanyane District of the Eastern Free State (Group C - Fig. 3.3), in which the study was introduced to them and to commence data collection.

Data was collected in the Free State Province during 2012 (Group C) and 2014 (Group D - Fig. 3.3) by means of e-mailed questionnaires. The 2014-Questionnaire differed

from the 2012 Questionnaire in that it contained pre-defined lists for participants to choose from, to ensure standardisation of data.

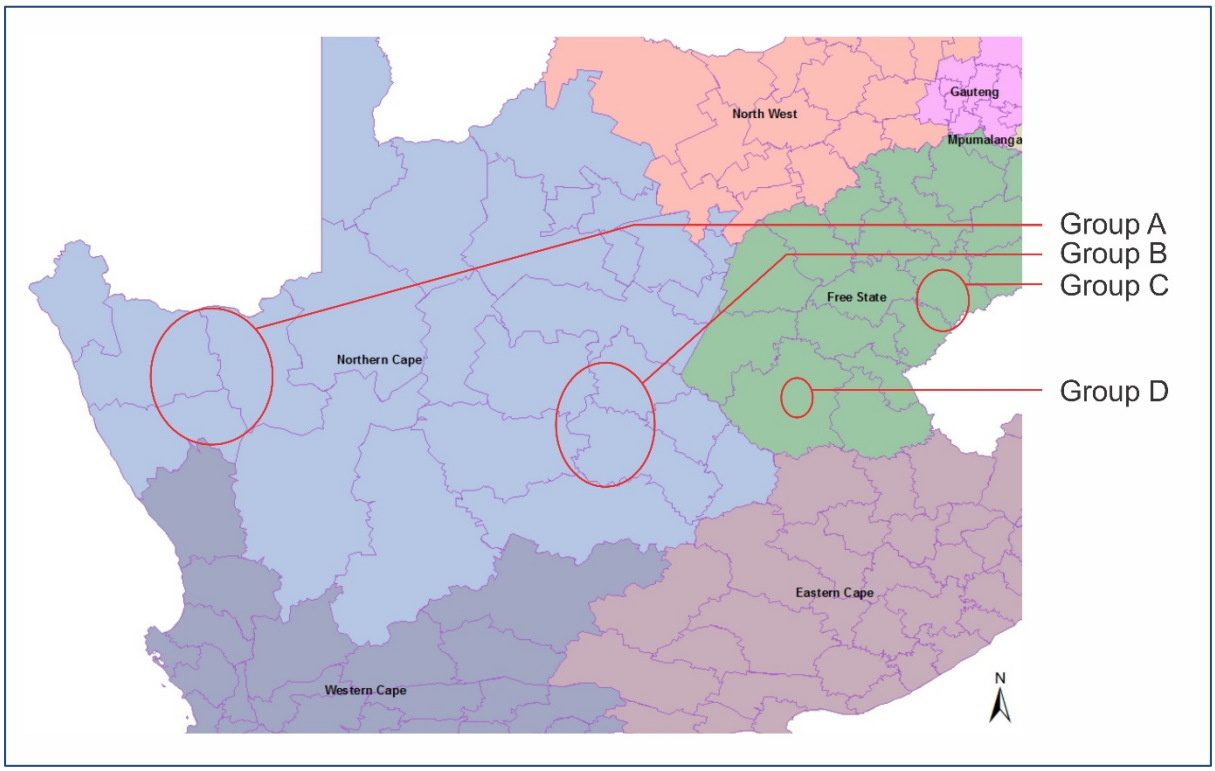

Figure 3.3 The four areas (Groups A to D) from which data were collected from livestock farmers since 2011.

The data collected from these four groups (A, B, C & D) were then used to develop and test the software used in this study. At first, a computer programme (desktop application) was developed and tested, which ultimately led to the development of mobile device applications for collecting data on predation management (Chapter 5). This process assisted in highlighting areas where coordination of efforts is needed, and where the data collected with the aid of the mobile applications may, in turn, be of use to promote coordination with regard to predation management in South Africa.

3.2.2 Predator control data provided by specialist predator hunters

Data on predator control collected with the questionnaires (Groups A, B, C, and D) were used to test the application designed for collecting data regarding predator control activities.

In October 2018, a group of professional predator control specialists (Group E) was addressed during a meeting and introduced to the mobile device applications. They were also given a background on the functions and progress of the PMiC, and the role of scientific research in coordinated predation management was explained. The applications were then installed onto the mobile devices of those (n = 9) who were interested in testing them in the field. The area covered by Group E is shown in Figure 3.4.

3.3 Development of questionnaires and digital data collection tools

The present study comprised the use and development (evolution) of a progression of questionnaires and software to develop a method of data collection that combines the advantages of field studies with those of surveys.

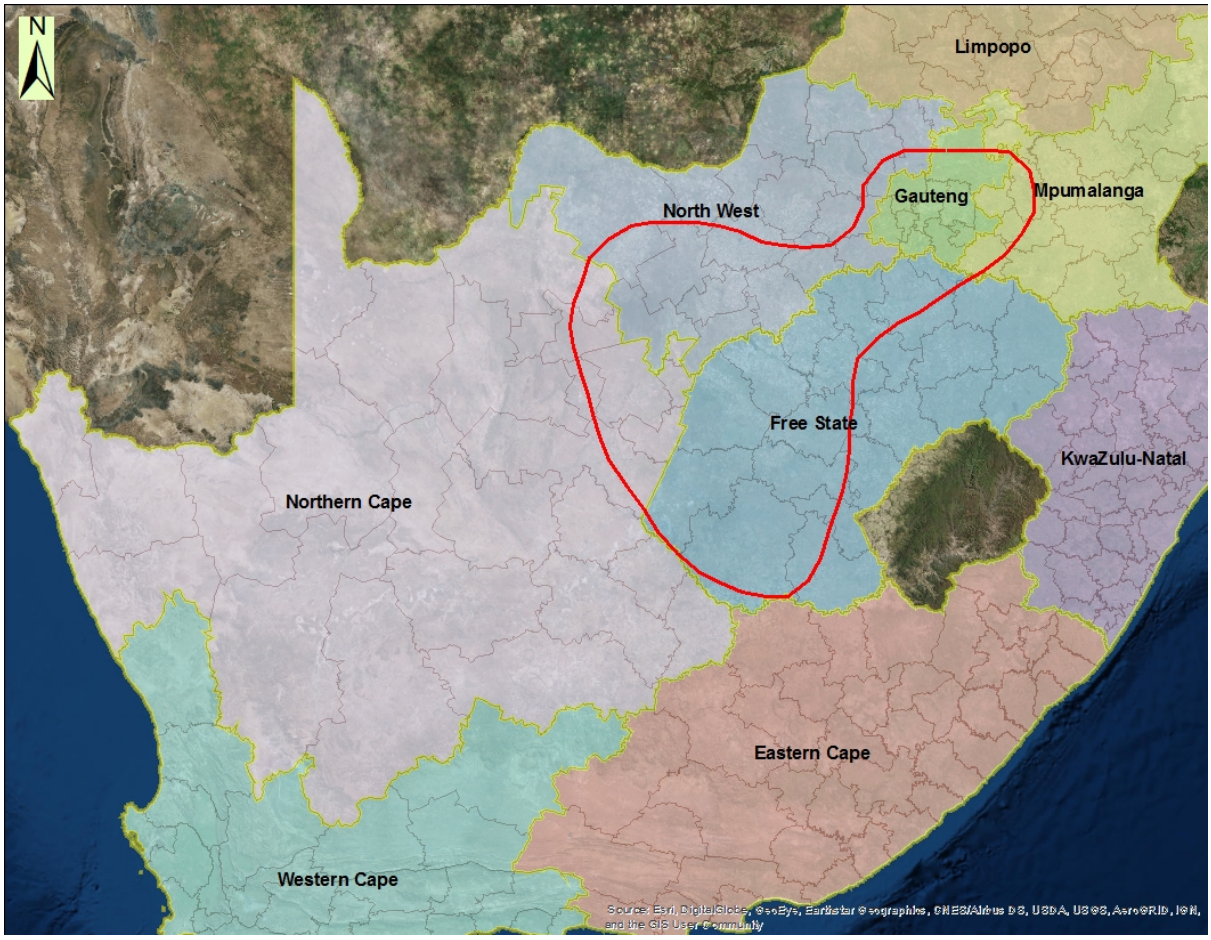

Figure 3.4 The area in South Africa covered by the data received from professional predator control specialists, Group E.

3.3.1 Questionnaires

Similar to the procedure adopted by Potgieter (2011), three different versions of questionnaires were used, each named according to the year during which it was used for collecting data (namely the 2011-, 2012- and 2014-Questionnaires – Appendix 1). The standard questionnaires (the 2011-Questionnaires) used at the start of this study were paper-based and submitted via mail or e-mail. They were based on the forms proposed by Gunter (2008) and the questionnaires used by Van Niekerk (2010). As the study progressed, minor alterations were made to the 2011-Questionnaires. The purpose of the alterations was to make the questionnaires more comprehensive, to simplify the process of recording data for participants (refining fields which participants may find confusing), and to ensure some measure of standardisation of data. The next two sets of questionnaires (the 2012- and 2014-Questionnaires) were completed in MS Excel format and e-mailed back by the respondents.

In Groups A - D (Fig. 3.3), one person was designated to help coordinate data collection and assist in upholding continued participation by farmers in that area. Participants were reminded monthly by e-mail to submit questionnaires. No personal interviews or farm visits were conducted in this study.

The method of self-administered questionnaires was used initially because the study was intended as a follow-up to that of Van Niekerk (2010). Having participated in the study by Van Niekerk (2010), some of the farmers were therefore already familiar with the goals of the Canis-Caracal Programme (CCP). Furthermore, self-administered questionnaires were used to promote more truthful reporting, since respondents may edit information for fear of embarrassment or persecution (Tourangeau & Yan, 2007; Thorn *et al*., 2013), or where sensitive information such as the income generated from production is concerned.

In contrast to opinion surveys which mainly make use of semi-structured questionnaires (Davie *et al.*, 2014), data was collected in this study using structured questionnaires consisting of mainly closed-ended questions. With few open-ended and partially open questions, some measure of standardisation of the data can be achieved. However, when it became apparent that this was not enough to ensure standardisation, further measures were put in place to achieve a higher level of

standardisation (see Appendix 1). The result was the development of a methodology for future predation management studies.

Similar to the data collection methods used by Robel *et al*. (1981) and Lawson (1989), the questionnaires used in this study consisted of two parts (see Appendix 1). The evolution of the questionnaires resulted in Part 1 consisting of fields for collecting information on personal detail of each livestock farmer, management practices on the farm, predation management techniques (lethal control of predators, as well as non-lethal or preventive measures) and the frequency with which they are used. Similarly, the final version of Part 2 of the questionnaire (2014-Questionnaire) contained fields for recording only the necessary detail regarding livestock and wildlife losses and predator control on a monthly basis. The methodology developed in this study makes use of mobile device applications (Section 3.3.2) instead of Part 2 of the questionnaires, while still employing Part 1 to collect additional data to gain insights on determinants of human-predator conflict on farm level.

3.3.2 Software

Gunter (2008) developed and tested computer software for capturing data on predation management, isolating specific subsets of the data with the aid of the built-in queries and exporting it to the appropriate format to incorporate the georeferenced data in Geographic Information Systems (GIS). Although displaying the data on maps in GIS may aid in the interpretation of data, shortcomings in the historical (pre-1990) dataset still prevented meaningful analyses of the data (Gunter, 2008). Therefore, Gunter (2008) proposed that a new format be used for the collection of more detailed data. Such detail included the date and location of each predation incident and predator control activity on a farm, as well as the species (goat, sheep, cattle), sex and age of animals killed by predators, the species, age, sex and stomach content of each animal killed or caught in the control operation, the method used in each control operation, and whether the animal killed or caught was the target animal (animal suspected of predation). Such data provide valuable basic information regarding the ecology of predators and possible reasons for livestock predation (Grafton, 1965). Recording stomach contents also provides an indication of the accuracy with which

farmers and ranchers identify predators responsible for causing damage (Bussiahn, 1997).

In the present study, the desktop application used by Gunter (2008) was modified to facilitate collection of additional information regarding personal details of each participating farmer, as well as physical attributes of and management practised on each farm (Fig. 4.1). The process of developing the software ran concurrent to the process of developing the questionnaires. Therefore, the desktop application (Fig. 4.1) developed at the start of this study resembled the 2011-Questionnaires (Appendix 1).

This version of the desktop application was tested with the data obtained with the use of the 2011-Questionnaire, and it became apparent that it was not user-friendly. For this reason, in addition to the challenges associated with the use of questionnaires, a number of alternative methods for data collection were explored to provide those directly involved in predation management with a non-intrusive means to report on human-predator conflicts. These included mobile text messaging (SMS) and e-mail messages making use of comma-separated values (CSV), MS Access and MS Excel databases, EvaSys Survey Automation Suite v4.0 and mobile device applications for data collection.

These methods and the questionnaires were lacking in terms of standardisation and accuracy of data and offering a means to obtain the exact locations and dates of predation incidents vs predator control. Furthermore, with the increasing popularity and utility of mobile technology, the focus shifted to finding mobile software which makes use of the built-in GPS technology of mobile devices to enable automatic recording of such information.

The collection of large amounts of data on a continuous basis, as envisioned for a coordinated system of predation management, calls for an efficient system of data handling and analysis. Therefore, a tool in the form of mobile device applications was developed with the aid of CyberTracker software. The use of this technology allows for collecting accurate, real-time data on predation losses and predator control, covering large areas and extended periods. In addition, it has the potential to provide

participants with a non-intrusive method of reporting human-predator conflict in a way that is less time-consuming and reduces the misreporting of valuable information.

Initially, it was endeavoured to develop a single mobile device application for collecting all the data required in both Part 1 and Part 2 of the questionnaires (Appendix 1). The application was designed to serve as an aid in general farm management activities in addition to recording predation (see Section 4.4.2), to serve as incentive for farmers to use the application. However, due to the resulting large database making data handling and analysis arduous, and the fact that many livestock farmers make use of specialist predator hunters to assist in predator control, the application was split into two separate components, namely an application for recording only predation (Chapter 5) and an application for recording only predator control activities (Chapter 6). In so doing, specialist predator hunters could also be provided with an application to record their activities. Supplemental data would still be collected utilising questionnaires (Section 3.3.1) to ensure that the mobile applications remain user-friendly and to promote engagement with livestock farmers, wildlife ranchers, and predation management specialists (specialist predator hunters and government officials tasked with predation management activities).

3.3.3 Maps

ArcGIS maps, obtained from the Geography Department at the University of the Free State (UFS), were used to identify areas in which predation was reported in the study by Van Niekerk (2010 – Figure 3.2). Where farmers did not supply GPS coordinates for the farms they listed in the questionnaires, the farms were located from electronic topographic maps provided by the NGI (National Geo-Spatial Information). GPS coordinates were taken from *ca* the middle of these farms, by means of the maps obtained from the UFS Geography Department. Maps were created using ArcGIS 10.6 and ArcGIS Online to display the predation and predator control data supplied in the questionnaires.

The following three chapters (Chapters 4, 5 and 6) describe the evolution of a methodology which includes a tool to accommodate the collection of large amounts of reliable information on predation and predation management. If incorporated in a

Management Information System (MIS), data collected in this manner may provide a means to (a) determine the current situation surrounding predation management in South Africa, (b) fill gaps in scientific research on predation management, and (c) serve as the basis for development and evaluation of adaptive management approaches.

4 Advances in overcoming the shortcomings of collecting current data using questionnaires

Effective human-predator conflict mitigation is dependent on a thorough understanding of the drivers behind predation and factors at play in managing damage-causing predators. Therefore, information (obtained over large areas and also over extended periods) containing sufficient detail to conduct meaningful analyses, is integral to informing predation management in South Africa. This chapter describes the use of questionnaires as the first step to collect standardised, detailed longitudinal data on predation management. Valuable lessons were learnt with the use of questionnaires, and it is important to highlight the potential of such detailed data collected on farm level, but also the underlying social aspects at play in the field of human-predator conflict in South Africa.

The modified hunt reports suggested, and software used by Gunter (2008) provided for collecting data on predation incidents and predator control operations in reaction to predation. However, human-predator conflict is also influenced by other factors (see Section 4.1). Therefore, questionnaires and software were developed in this study to facilitate collection of data that may provide insights into specific sets of circumstances in efforts to better understand the drivers of the conflict on farm level as well as on a larger scale. The aim of developing software was to provide farmers and specialist predator hunters with a user-friendly tool to record predation management data, which are then incorporated into a database from which various studies can be conducted. However, at the start of the study (2011), computer software still posed challenges as a data collection method, and the use of mobile applications for recording data was not commonplace. Therefore, questionnaires were initially used to obtain the necessary information while improving the software, and ultimately developing an alternative methodology to serve this purpose.

4.1 Expected outcomes from questionnaire design

Factors influencing human-predator conflict include the size and type of farming enterprise (sheep, goat, cattle, crops, wildlife ranches or combinations), farm management practices such as stocking rates, livestock breed or wildlife species,

husbandry practices, intensity of predator control and prevention practices, spatial, temporal and environmental factors, predator biology and behaviour, level of livestock predation, as well as social elements (Lensing & Joubert, 1976; Knowlton *et al.*, 1999; McAdoo & Glimp, 2000; Blaum *et al*., 2009; Inskip & Zimmerman, 2009; Van Niekerk, 2010; Potgieter, 2011; Thorn *et al.*, 2013; Badenhorst, 2014; Schepers, 2016; Du Plessis *et al*., 2018).

The questionnaires used in this study (included in **Appendix 1**) were designed to allow investigation into:

- the extent and spatio-temporal distribution of livestock losses in an area
- predation losses as compared to losses due to other causes
- predation losses as caused by different predator species – including prey preferences among different predator species, such as species, breed, sex and age classes of livestock
- the influence of size and type of farming enterprise, as well as seasonal and regional factors on differences in the intensity of predation by different predator species on livestock
- predation losses per unit area, or as a percentage of
    - total flock/herd size on farm, local, regional, or provincial level
    - annual livestock increase or production on farm level or per individual farmer
    - potential income on farm level or per individual farmer
- the efficacy of different management strategies (no predation management, compared to non-lethal, lethal or combinations of lethal and non-lethal management) in reducing or preventing predation on a farm
- the influence of predator behaviour, biology and ecology, and environmental factors on the management of a particular species of damage-causing predator in an area
- socio-political factors influencing the situation in a particular area.

4.2 Implications of using questionnaires to collect data

Factors influencing the collection of detailed longitudinal data with the aid of questionnaires are described here, as well as its effect on interpretation of the results from Groups A - D.

4.2.1 Overall Response

Despite one person from each group being designated to assist in the coordination of questionnaire submission among the farmers and reminders being sent to the respective farmers, overall response (number of questionnaires received from farmers) from all four groups in this part of the study was relatively poor (Table 4.1).

Response from Group A was good initially, but their response waned as the study progressed. Participation decreased every month until no more questionnaires were received by March 2012. Despite a 52% decrease in overall response by the second month (June 2011) of the study period, farmers maintained a comparatively good response rate up to the fourth month (August 2011) of the study period. Response continued to decline until no more questionnaires were received by the 11th month (March 2012) of data collection from this group.

Response from Group B was good only on the day this group was visited. Only one questionnaire was received the following month, while participation ceased completely by the third month (September 2011) of data collection from this group.

Overall response from Groups C and D was poor from the outset. In Group C, only four (4) of the 11 farmers who received questionnaires returned completed questionnaires during the first month (March 2012). Of these four farmers, only two continued submitting questionnaires up to the 6th month of the study (August 2012), after which no more questionnaires were received. In Group D, response was received from only one of the 10 farmers who indicated their interest in participating in the study. Questionnaires covering for a period of seven (7) months were received from this farmer.

4.2.2 Item response

Despite provision being made in the questionnaires for recording more detail, explaining the aim of recording such detail and farmers being guided through the process of completing questionnaires, questionnaires were still not completed uniformly. In addition, follow-up communication with farmers was ineffective in

obtaining additional information, such as the location of farms, or verifying particulars regarding information reported. The results obtained from these questionnaires are discussed in Chapter 7 to illustrate the value of a detailed set of continuous data to managers.

The highest item response (most/all of the fields/questions contained in the questionnaires completed) in Group A was received from three farmers who also had the highest overall response. The questionnaires included detail such as GPS co-ordinates for each farm as well as dates for each of the livestock losses experienced and predator control operations carried out.

Only one farmer from Group B submitted Part 2 of the questionnaire; therefore, no comments can be made regarding item response received from this group. Despite the low overall response from Groups C and D, item response was comparatively good.

Discussing some of the underlying social factors encountered in attempts to collect data with means questionnaires is important to provide context to the inadequate overall and item response throughout this part of the study.

4.2.3 Additional efforts at data collection

In a presentation delivered in 2011 at the 7th International Wildlife Symposium in Kimberley (De Waal *et al*., 2011), previous predation management research conducted at the University of the Free State and the goal of ongoing research was described at length. In response, a farmer who attended the Symposium showed interest in participating in the present study. However, despite several e-mail communications with this farmer and his apparent enthusiasm to participate in the study, no successful data collection could be established.

Table 4.1 Summary of response to questionnaire surveys from Group A – D, including total livestock losses and predator control reported for each group.

Group	Number of participating farmers	Number of farms covered in completed questionnaires	Number of months covered	Livestock losses due to predation			Livestock losses due to other causes	Predators removed using lethal control methods		
				Black-backed jackal	Caracal	Other predators		Black-backed jackal	Caracal	Other predators
A	25	35	10	288	190	25	152	67	34	13
B	21	47	2	320	33	0	108	48	32	0
C	4	15	6	17	0	0	0	11	1	0
D	1	3	7	1	0	0	0	1	0	4

Following the Predation Management Information day held in Beaufort West, Western Cape Province on 20 October 2011, a government official from the Department of Agriculture, Western Cape Province, indicated that he was instructed by a supervisor to collect data locally for use in the study (Theron, 2011). Therefore, questionnaires were forwarded to the official to distribute among farmers in the area.

By March 2012, the official reported that only three questionnaires were returned by farmers (out of a total of 35 questionnaires distributed), while one farmer refused to complete the questionnaires. According to the official, farmers were sceptic about disclosing information for fear of misuse or that it may end up in the hands of environmental or animal rights activists. Furthermore, he indicated that many farmers simply do not “work with paper”. As a result, he did not see it fit to send only the three questionnaires submitted to him and did not make any further attempts at data collection in this area (Theron, 2012).

Similarly, following the Technology Transfer on Predation Management held on 16 February 2012 at the Glen Agricultural Institute, Free State Province, some farmers indicated their interest in participation in the study. Besides for Group C, successful data collection from the other farmers who indicated their interest to participate in the study could not be established. One of the farmers pointed out that the area where he farms experienced heavy predation (south-eastern Free State Province) and that other farmers in that area were interested in participating in the study. However, despite several electronic communications as well as a meeting with this farmer, no success was achieved in launching a study in that area, and attempts to collect data were fruitless. The farmer also supplied contact information of farmers’ associations to contact in efforts to launch the study in those areas. However, unsuccessful attempts to schedule meetings with these associations also impeded data collection here.

4.2.4 The role of human dimensions in collecting data on a controversial topic

Completing questionnaires on a monthly basis is an effective way to obtain fairly precise numbers for predation losses as well as predator control. However, it is also an intrusive method in terms of time and effort on the part of respondents. The arduous nature of filling in questionnaires was one of the concerns voiced by a farmer from

Group C, and may have been the most important factor responsible for the decline in overall response. In combination with other factors, it may explain the poor overall response from Groups A - D. These factors include:

- an aversion for “working with paper” (Section 4.2.3);
- lack of interest in participating in surveys;
- concerns over the improper use of the information supplied;
- farmers’ expectations in terms of feedback and assistance with their predation problems;
- farmers’ distrust regarding the motives behind research;
- farmers’ distrust of the Government and some NGOs; and
- other underlying social factors, such as previous negative experience in a survey, or lack of feedback from previous processes.

Research based on surveys depends to a large degree on the public’s willingness to participate (Molenaar, 1991; Bergold & Thomas, 2012) and the method of collecting data. Evidence exists that people’s attitudes toward surveys become more unfavourable the greater the number of times they are asked to participate (Molenaar, 1991). To date, several surveys have been conducted in South Africa regarding predation (Brand, 1989; Lawson, 1998; Van Niekerk, 2010; Thorn *et al.*, 2012; 2013; Badenhorst, 2014; Davie *et al.*, 2014; Constant *et al.,* 2015; Scheepers, 2016), often in isolation and uncoordinated, which may cause farmers to lose interest in participating in surveys.

Relatively poor response to surveys has been demonstrated in several studies conducted in southern Africa, particularly with regard to studies which made use of mailed questionnaires (Lensing & Joubert, 1976; Brand, 1989; Lawson, 1989; Anche Schepers, 2016 personal communication; Chavoux Luyt, 2018 personal communication).

Another contributing factor which may have influenced the level of participation is farmer expectations. According to Decker *et al.* (2002), communities affected by wildlife damage are inclined to (a) expect immediate and undivided attention from Government; (b) desire significant involvement in management planning and decision

making; and (c) want swift, no-cost, permanent solutions to wildlife damage issues. These were also among the concerns voiced by farmers during the course of the study.

In addition, the nature of the feedback due to the limited data received may not have met the expectations of the farmers, causing some to lose interest. The fragmented nature of the data received in this study impeded meaningful feedback to respondents. Reports were generated from the data, containing summaries of the data received, and sent to each group. However, farmers could not be informed on trends/general predation characteristics in their area, nor could reports from different areas be compared. Providing farmers with reports of activity on their own farms may be of little value to some, and may thus have further contributed to the decline in farmer participation over time.

Moreover, assurances of confidentiality of information may influence both overall and item response. Although the public may not object to surveys as such, many remain suspicious of the motives behind a survey (Molenaar, 1991). According to Alwin (1991), the assurance of protecting the confidentiality of information received is often insufficient to encourage farmers to disclose any sensitive information, which seems to have been at least partly the case in the present study. Some farmers did voice their concerns over the use of the information supplied by them, fearing that the information may “fall into the wrong hands” (government or environmental or animal rights activists). In some instances, confidentiality assurances may even reduce overall response rates (Tourangeau & Yan, 2007).

Other social factors came to light during the course of the study, as demonstrated by Group B. The reaction of one farmer from Group B to follow-up e-mails (reminders to submit questionnaires) was that he did not wish to participate in the study, as he was already working with a predation management specialist/researcher in the area. It was later learned that the general consensus among this group of farmers was to cease any further participation in the study because some of the farmers were already involved in a predation monitoring project conducted by this individual.

This sentiment may also have spilled over to other areas in the broader region, hampering attempts to collect data in three other areas which have been identified for

data collection initially (Section 3.2). Furthermore, it later came to light that a small number of individuals who attended the working session may have influenced other individuals in the group to cease participation in the project. A similar situation presented itself with Group E (see Chapter 6).

4.2.5 Interpretation of results

The decline in participation and low item response hampered in-depth analysis of the predation and predation management situation for each of the four groups of farmers in this study. The lack of comparable data and small group sizes in this study also prevented comparison of the results from the Free State Province (Groups C and D) between the present study and that of Van Niekerk (2010). A summary of the overall predation and predator control numbers from Groups A and B are given here, as compared to results reported by Van Niekerk (2010) for the Northern Cape Province.

4.2.5.1 Livestock losses

Predation accounted for 77% of all livestock losses reported for the two groups (Groups A and B) in the Northern Cape Province, compared to 96% reported by Van Niekerk (2010). The loss of 0.8% of the total flock size reported in this study is considerably lower than the 6.14% loss reported by Van Niekerk (2010). However, it is slightly higher than the 1-2% reported by Brand (1993) for the erstwhile Cape Province. These results highlight the effect of different sample sizes and methods of data collection on the results of studies. The decrease in participation precluded interpretation of seasonal trends in predation losses.

4.2.5.2 Non-lethal predation management

In this study, 97.62% of the Northern Cape farmers reported using non-lethal methods, compared to the 87% reported by Van Niekerk (2010). Jackal-proof fencing was the most common non-lethal predation management method reported by Northern Cape farmers in this study (Groups A and B) with 88.1% of farmers making use of this method, compared to 45% reported by Van Niekerk (2010). This difference may be explained by the present study covering only two districts in the Northern Cape Province, while the study by Van Niekerk (2010) covered the entire province (5 districts). Generally, jackal-proof fencing was used in combination with other

preventive methods, with electric fencing being the most popular in Group A, and bells as auditory deterrents in Group B.

In contrast with Van Niekerk (2010), who reported the main lambing seasons in the Northern Cape as being during March to April and August to September, the main lambing seasons reported for the present study was from April to June. The April to June lambing season coincides with the time during which most livestock losses were reported (May to August) for this study, and with the mating season of black-backed jackal (Bothma, 1971a). The differences may be a result of farmers adapting their management practices since the conclusion of the study by Van Niekerk (2010) - which may also explain the lower predation reported in this study - or may simply be a result of the smaller sample size and the present study not covering the entire Northern Cape Province.

4.2.5.3 Predator control

Compared to the 90% reported by Van Niekerk (2010), 97.62% of the responding farmers in Northern Cape used lethal methods (predator control). These methods were used in combination with non-lethal predation management methods. The most popular methods were hunting, foothold traps (see Saffy & De Waal, 2010) and cage traps, which is in agreement with the findings of Van Niekerk (2010). Three farmers from Group A reportedly did not make use of any lethal methods, while one farmer in Group B reported making use of only lethal (predator control) methods as predation management strategy. The decrease in participation precluded investigation into seasonal trends in numbers of predators removed, and thus the relationship between predation losses and predators removed.

4.3 Lessons learnt from the use of questionnaires

Despite widespread communication with various groups during the course of this study regarding the Canis-Caracal Programme (CCP – Section 1.3) and the role this study would fulfil in the CCP (De Waal, 2020), there are still numerous underlying factors impeding the development of a coordinated system of predation management in South Africa. Therefore, future attempts at a coordinated approach to predation management will require a strong focus on social elements, or the “human dimensions” of predation

management (Du Plessis, 2013) through longitudinal engagement (frequent contact sessions) with farmers (Constant *et al*., 2015). A vital aspect of longitudinal engagement with farmers in future research will be continuous evaluation of their perceptions of a predation management programme and incorporating their inputs to ensure sustainability of the programme.

Valuable data were obtained through the use of questionnaires in this study but were not enough to achieve in-depth study of predation management practised in an area. The information collected by means of questionnaires could not satisfy the needs initially set out, namely in-depth investigation into the predation situation in the Northern Cape Province, as reported by Van Niekerk (2010). The incomplete data sets due to poor overall and item response was the main factor hampering investigation into the factors listed in Section 4.1. Furthermore, a lack of standardised data complicates data handling and analysis (Will *et al*., 2014) and reduces the number of records that can be used for detailed analysis.

A decrease in participation by respondents may also lead to the perception that predation and predator control numbers seem to decrease over time (Section 4.2.5). Therefore, the aspect of participation needs careful consideration in future predation management research making use of the methodology proposed in this study. Concrete data is necessary to study the trends in non-response and to determine the causes. Studying the social conditions which may affect response rate, or studying the problems and aspects of non-response itself may be valuable for fine-tuning the methodology or provide insights into different approaches to consider to increase response rate (Molenaar, 1991).

Reliable, continuous data need to be collected on a large scale and over an extended period from individuals in a particular area to obtain a more accurate picture of the situation in that area. Conducting research in line with a coordinated predation management system may benefit from the use of incentives to promote participation in the collection of data on a large scale. Though financial incentives may not be in the scope of the NGOs involved with predation management, or even government departments, negative incentives such as that implemented by CapeNature have been successful in collecting predation management data. In its cooperative agreement with

the Western Cape Predation Management Forum (PMF), Cape Nature required specialist predator hunters to report on their predator control activities to apply for renewal of their permits. Similarly, farmers who needed to control damage-causing threatened or protected species were required to supply detailed data on the predation incident(s) to apply for a permit to conduct predator control. For the control of damage-causing animals which are not listed as threatened or protected, however, farmers do not require permits and other forms of incentive should be considered.

As with Gunter (2008), locating those farms for which co-ordinates were not supplied was difficult and time-consuming. While some farmers in this study were able to supply GPS co-ordinates to indicate the location of their farms (homestead), acquiring exact locations of predation incidents vs predator control activities remained a major shortcoming throughout the study. In addition, few farmers supplied the dates on which predation incidents occurred and predator control activities were carried out, although provision was made in the questionnaires to record such detail (**Appendix 1**).

Qualitative data collected with the use of questionnaires provided valuable contextual background. These include farmers' perceptions of the predation problem experienced on individual properties as well as over larger areas (e.g. in a district or province); specific observations with regard to predator behaviour/ecology in an area; participants' personal accounts regarding the success or practical and financial implications of particular predation management methods.

4.4 Escalating data collection from cumbersome questionnaires to mobile device applications

Obtaining accurate estimates of predation in South Africa remains a challenge. Van Niekerk (2010), Badenhorst (2014) and Schepers (2016) investigated the extent and distribution of predation on small livestock farms, large livestock farms and wildlife ranches, respectively. Large areas were covered, producing large data sets covering two years.

This study aimed to conduct more in-depth investigations into predation management on farm-level, and ultimately develop a methodology to conduct continuous

investigations to inform predation management strategies, serve as a tool for evaluation and monitoring, and facilitate coordinated predation management. This methodology makes use of mobile technology for the collection of data on a large scale. Although such technology is useful for collecting the most important data for management purposes, the methodology could not abandon the use of questionnaires completely. The questionnaire to be used as part of the methodology proposed here serves to maintain user-friendliness of the mobile device applications by collecting the contextual information necessary to gain insights into the unique physical and managerial aspects of each farming enterprise to be investigated. Administering the questionnaires through engagement with livestock farmers, wildlife ranchers and predation management specialists (including government officials) also presents the opportunity to address many of the social aspects of predation management.

4.4.1 Limitations of conventional data collection methods

Conventional data collection techniques such as surveys with questionnaires and interviews can be time-consuming and arduous (Knowlton *et al.*, 1999), and may provide subjective and misleading information (Graham *et al.,* 2005), as they are subject to certain biases. However, collecting data in this way is an important first step toward the development of effective mitigation strategies given the paucity of data that exists in South Africa (Thorn *et al.*, 2012).

Questionnaire surveys are subject to non-response bias (Connolly, 1978; Brand, 1989; Knowlton *et al.*, 1999; Decker *et al.*, 2002, Chavoux Luyt, 2015 personal communication; Schepers, 2016 personal communication; this study), resulting in low overall response. With the exception of cases where livestock farmers and wildlife ranchers keep accurate records of the predation and predator control numbers on their properties, data collected through interviews and surveys Van Niekerk, 2010, Badenhorst, 2014; Schepers, 2016) are subject to recall bias (Connolly, 1978; Decker *et al.*, 2002). Data from questionnaire surveys and interviews are subject to the degree to which producers locate missing animals and determine the cause of death of their livestock/game (Connolly, 1978; Lawson, 1989; Knowlton *et al.*, 1999; Du Plessis, 2013). Moreover, the low item response rate (Chavoux Luyt, 2015 personal communication; Anche Schepers, 2016 personal communication; this study)

associated with mailed questionnaires, results in data sets containing little useful information.

Exaggerated losses in pursuit of ulterior motives (Graham *et al.,* 2005, Thorn *et al.*, 2013), and social desirability bias (socially acceptable rather than truthful answers) may also result in inaccurate numbers (Decker *et al*., 2002). Such over- or underestimations associated with questionnaires often render the value of the data obtained questionable (Lensing & Joubert, 1976; Bearzi & Saylan, 2008).

The most accurate data on losses is obtained with field studies and data from compensation schemes, although conducting field studies is the most time-consuming and expensive method compared to other methods (Connolly, 1978; Knowlton *et al.*, 1999; Schiess-Meier *et al.,* 2007; Du Plessis, 2013). Reliable data is collected through rigorous verification of livestock predation to avoid misrepresentation of loss rates. Spatial and temporal patterns of predation can be accurately portrayed by recording details such as the date and exact location for each predation incident (Stahl *et al.*, 2001; Ogada *et al.,* 2003), while predation patterns for different predators in different areas and for different age and sex classes of livestock types can also be examined (Sangay & Vernes, 2008). Traditionally such studies do not account for, nor identify, all causes of loss. However, with compensation schemes usually being run as coordinated systems of predation management, identification of or accounting for other causes of loss may be achieved by supplementing information with other data obtained from government records or data from interviews. Such data may include the size of livestock herds/flocks in different areas and livestock losses due to reasons other than predation (Stahl *et al.*, 2001; Schiess-Meier *et al.,* 2007).

Studies conducted with farm records can also provide reliable data (Avenant *et al.*, 2009), but each farmer keeps record in a different way, which means that results will often not be comparable. These studies cover only small areas at a time, which means that samples are not large enough for generalisation of findings.

4.4.2 Evolution of the software

The desktop application used by Gunter (2008) was used as point of departure in the present study to refine the software designed specifically for collecting predation management data (Section 3.3.2). Since farm management and husbandry practices are among the factors which influence predation, provision was made in the desktop application used in this study to enable suitable analysis on farm level and to compare with data from different farms, regions and timeframes. The data collected by means of the questionnaires in this study were used to test the modified desktop application (Fig. 4.1). Owing to the amount and nature of data to be collected, however, developing a user-friendly version proved challenging.

As the present study progressed, it became evident that some form of incentive is necessary to ensure continued use of the desktop application by livestock farmers and wildlife ranchers. Therefore, the software was modified to present farmers and ranchers with a means to record predation management data and enabling them to generate their own reports to assist in monitoring and improving their management strategies (Fig. 4.1).

The data collected by means of the questionnaires were also used to test the other computer technologies explored in this study (see Section 3.3.2; Appendix 1) for data collection. However, because each of these methods was lacking in various respects, their use is briefly discussed in Appendix 1. The amount and nature of the data to be collected created challenges in designing the methods in such a way that they were user-friendly. Formats which are not user-friendly would likely discourage many to supply such data. Furthermore, with the exception of sending data via SMS, these methods did not allow for recording predation management data in the field, and none of the methods explored above offered a means to automatically record exact dates and locations. Therefore, once the technology became available for collecting data with mobile phones and other mobile devices, any further investigation into any of the abovementioned methods became impractical.

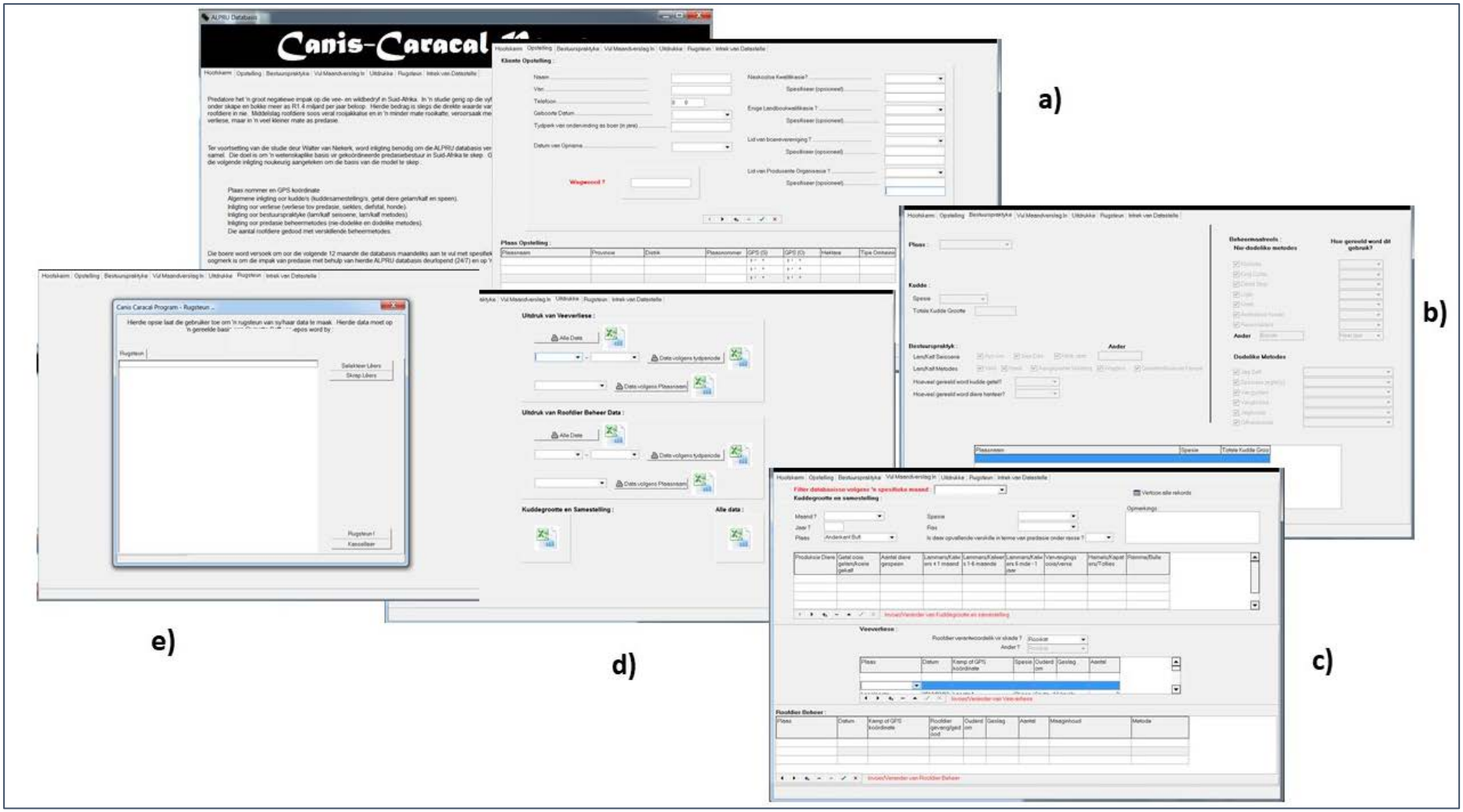

Figure 4.1 Screens contained in the desktop application adapted from the software used by Gunter (2008), allowing for the collection of: (a) basic information regarding the farmer and physical characteristics of the farm(s), (b) farm, herd and predation management practices; (c) monthly reports on predation and predator control; (d) filtering specific data sets for import into the GIS environment; and (e) sending the data to the person/institution conducting the research.

Efforts were accelerated in 2014 to find software with the potential to combine some of the advantages of conventional data collection methods, while reducing or eliminating many of the associated disadvantages. GPS technology currently available presents the opportunity to record the date, time and location of a particular activity. Mobile GIS configurations available at present typically consist of a hand-held Personal Digital Assistant (PDA) running Geographic Information System (GIS) software and linked with a Global Positioning System (GPS), or smartphones with built-in GPS which combine these features into one instrument (Mccall & Dunn, 2012). However, few of these technologies are capable of satisfying the needs of scientific research.

CyberTracker software appeared to be the best option to collect real-time, reliable and detailed georeferenced data, in a way that is time and cost-effective (Bearzi & Saylan, 2008; Drill, 2013). It was the only software freely available, which was designed to accommodate data collection in the field. It was therefore chosen to further the development of a method for reporting predation management data with ease and on a voluntary basis (see Chapters 5 and 6).

The CyberTracker system was designed to be user-friendly, facilitating use among people unfamiliar with computer technology or even semiliterate or illiterate people (McCall & Dunn, 2012). Learning to apply the software requires no high-level technical skills, which may accommodate participation (McCall & Dunn, 2012), thus improving the poor overall response rate associated with mailed questionnaires (Decker *et al*., 2002).

Although CyberTracker software has been used in predation research before (Hawkins, 2012), these studies did not consider the software for collection of data on a large scale as part of participatory research. Banda (2016) proposed a mobile application for this purpose, although the proposed application lacked most of the indispensable information necessary for meaningful analysis. CyberTracker already meets the requirements for a mobile reporting tool, as highlighted by Banda (2016), while also providing basic mapping and reporting tools necessary for scientific analysis and presentation of the data collected.

The CyberTracker software application for mobile devices consists of the CyberTracker mobile client and the CyberTracker database or desktop server. It is a digital data collection system created initially for wildlife monitoring (Cybertracker, 2007), in which data is recorded onto the mobile device (PDA, tablet or smartphone) with the aid of data entry templates specifically designed for the research project. This data is correlated with spatial coordinates and entered into a central database while still in the field (Will *et al.*, 2014). Thus, saving a record automatically logs the date, time and the exact location of each sighting (Drill, 2013), providing an element of precision reporting that had only been possible in field studies or data from compensation schemes. Recording such details provides insights into the specific situation at a particular time or on a particular farm.

Controls such as pre-defined lists and options can be built in (Bearzi & Saylan, 2008) to ensure standardisation of data and reduced entry errors, thus improving the quality of the data. (See Chapters 5 and 6), as well as some degree of objectivity. Furthermore, the desired item response can be attained by making important fields (items or questions) compulsory, thereby requiring an answer to a particular question to enable the user to proceed to the next question.

Numerous questions can be asked, which means that a large amount of information can be acquired for the time and effort expended (Knowlton *et al.*, 1999; Decker *et al.*, 2002). Similar to surveys with questionnaires and interviews, an advantage of digital data collection applications is that the researcher has control over the order in which questions are asked (Chase *et al.*, 2000; Decker *et al.*, 2002). However, with this method there is no interviewer bias, as may be the case with interviews and questionnaire surveys (Decker *et al.*, 2002). Furthermore, the technology allows for collecting qualitative data (employing text or voice recordings), which may provide contextual information in terms of predation management different or collecting information on respondent opinions to represent stakeholder interests (Decker *et al*., 2002). This combines the advantages of field studies with that of surveys with questionnaires and interviews.

Similar to the software used by Gunter (2008), the built-in queries then allow for filtering specific subsets of the data to assist in the analysis of individual subsets of the

data in the GIS environment. The use of visual aid (such as GIS maps) also plays an integral part in making research findings easier to understand, reaching a wider audience and providing stakeholders with a basis for further discussion (Bergold & Thomas, 2012).

Additional advantages of using the CyberTracker software to design mobile device applications for collecting predation management data include the following:

- Each application can be designed in such a way that fields and menus become available depending upon the user's choices, ensuring that the user only sees relevant screens (Will *et al.*, 2014).
- In 2018 it became possible to synchronise data collection in the field to a central database located on ArcGIS Online. The ability of CyberTracker to send the data from the user/client's mobile device to a remote database or central server is called "remote syncing". It greatly reduces the time and effort needed to collect data in the field and then transcribing the data into a database, eliminating human error associated with data transcription (McCall & Dunn, 2012). Thus, the effort required to maintain data sets is reduced (Will *et al.*, 2014). Communication via GPRS (General Packet Radio Service) between the mobile client and the desktop server allows for recorded data to be stored on the device when no coverage (signal) is available and have it sent to the server once coverage is available again (McCall & Dunn, 2012). The users' routine is not disrupted, and data collected is available for analysis on a real-time basis once it has been received. Access to timely summaries of field data can also improve decision making, such as where to prioritise management efforts, thereby increasing the cost-efficiency and success of wildlife management programmes. The use of GPS technology allows program coordinators to monitor the spatial and temporal progress of such a program (Will *et al.*, 2014).
- Except for an initial expense in terms of researchers travelling to areas to distribute the mobile application among groups of livestock farmers/specialist predator hunters who are to use it, the cost of data collection is low because the CyberTracker software is free and is combined with free satellite imagery (McCall & Dunn, 2012). Fields such as date, time, unique identifiers and GPS location are automatically recorded by the software and do not require user

input, saving time in the recording process and ensuring greater accuracy. Furthermore, the most significant advantage of this mode of data collection is the seamless integration of location and attribute information into a GIS (Will *et al.*, 2014).

- Scientists can design different templates for different types of research projects with ease (McCall & Dunn, 2012). This flexibility also allows individual scientists to make changes to a specific application to suit research in different areas or a specific set of circumstances.
- The utility of including photographs in a record lends credibility to the data collected (see Chapters 5 and 6) and may serve managers to assist farmers in particular situations. For example, it may assist in the identification of predator species responsible for damage in cases where farmers may experience some difficulty in doing so.

In efforts to promote the use of digital technology for reporting predation management among farmers, the initial application designed with the CyberTracker software for use on mobile devices was created to be used as a farm management tool. Other uses included recording daily farm management activities, monthly summaries (including rainfall, livestock counts, income generated, expenses, etc.) and general planning. Although this could serve as incentive for farmers to use the mobile application, it resulted in a database too large for research purposes, and also made the application less user-friendly (Chavoux Luyt, 2018 personal communication). Furthermore, there were indications that other software options available as farm management aids were also not popular among the farming community (Elmarie Swiegelaar, 2016 personal communication).

As a result, the application was split into two simple applications to be used for recording only predation incidents and predator control activities, respectively. A “Livestock & wildlife losses” application (see Chapter 5) was developed for recording livestock or wildlife losses observed in the field, and a “Predator control” application (see Chapter 6) for recording predator control activities as they are conducted in the field. The data collected with the aid of the applications do not provide insights into other factors which may influence predation management on a farm, such as the

physical characteristics and managerial aspects of the farm. Collecting such data will still require the use of questionnaires. Making the mobile device applications available to farmers, specialist predator hunters and government officials tasked with predation management necessitates visits to farming communities, providing the opportunity for scientists to engage with farmers and official wildlife managers for collecting the additional information by means of questionnaires (Part 1 of the 2014-Questionnaire). In the process, the aims and progress of research being conducted may be communicated to the group, while providing a platform for farmers to voice their concerns and engage with government departments regarding predation management issues and priorities.

5. Mobile device application for reporting predation

The extent of predation on livestock varies between different production enterprises, years, and seasons. The mobile device application described in this chapter was developed to allow investigation into these factors in an attempt to address the biases and other challenges associated with conventional data collection methods.

5.1 Designing the tool for reporting predation to address knowledge gaps

Conradie (2012) and Baily & Conradie (2013) investigated the effect of predator control on livestock losses from historical data and suggested an increase in livestock losses subsequent to the culling of predators on farms. Gunter (2008) also examined historical data (including the data set used by Baily & Conradie, 2013) and concluded that the hunt reports from the erstwhile government subsidised hunt clubs did not contain enough detail to investigate cause-and-effect of predator control on subsequent livestock losses. Brand (1989) further alluded to the inaccuracies in the data contained in the hunt reports of the subsidised hunt clubs. A key variable impeding the scientific analysis of the data was the fact that the information was not recorded in a standardised manner, due to differences in proficiency and motivation of hunters, different control methods used, and differences in administrative procedures followed.

Recent advances in research methodology have allowed for recording more detail for in-depth investigation into the prevailing situation in an area (Thorn *et al*., 2012; 2013; Constant *et al.,* 2015). Thorn *et al*. (2013) found no correlation between predation losses attributed to a particular predator species and the number of predators of that species removed in control operations. They instead concluded that the number of predators removed was subject to the availability of that particular species in an area, which is in agreement with the findings of Brand (1989). Nevertheless, research remains subject to financial, time, labour and geographical constraints, which preclude the evaluation and monitoring of existing and or proposed predation management practices, requiring a different approach to research for mitigating human-wildlife conflict in South Africa.

The technology used to create the mobile device applications provides for an element of accuracy similar to that of field studies and compensation schemes by allowing those farmers who are monitoring their herds or flocks to record each predation incident concisely and in a standardised format. At the same time, research may cover large areas and extended periods, containing larger samples that may be more representative of stakeholders (Knowlton *et al.*, 1999; Decker *et al.*, 2002; Drill, 2013; Will *et al.*, 2014). With reference to predation in the wildlife ranching sector, in particular, very little is known at present. The use of the applications may provide valuable insights into the efficacy of management currently practised to reduce predation, such as predator control, habitat modification and releases of farm-reared game, and other proposed methods (Graham *et al.*, 2005).

The “Livestock & wildlife losses” mobile device application (Fig. 5.1) was designed to record predation incidents as they are discovered or observed in the field, providing more accurate numbers by eliminating recall bias associated with interviews and surveys (Connolly, 1978; Decker *et al*., 2002). Obtaining data in this manner will also reduce misreporting of valuable information (Tourangeau & Yan, 2007; Thorn *et al*., 2013).

Although the mobile device application was designed specifically with predation in mind, livestock and wildlife losses can be recorded regardless of the cause of loss. Recording such detail will provide insights into the extent of predation relative to other livestock and wildlife losses, which may help authorities identify specific problems in a particular area (for example disease outbreaks or elevated levels of livestock theft). Priorities can then be set, and the appropriate resources and assistance be allocated to more precisely defined management zones (Treves *et al.*, 2004).

Recording livestock or wildlife losses, as they are observed or discovered in the field, addresses the issue of obtaining the exact locations and dates of predation incidents or other cause of loss (Section 4.3). The mobile technology allows for analysis of spatio-temporal trends in predation data received by automatically recording the GPS coordinates and date for each incident of livestock or wildlife loss. With only the most basic information collected using the “Livestock & wildlife losses” application (Fig. 5.2.1), maps can be generated showing the spatial and temporal distribution of losses

due to various causes, including predation on different types of livestock by different predator species.

In instances where livestock went missing, however, the exact date and location of the incident may be unknown because the livestock theft or suspected predation incident may go unnoticed until the next livestock count. Farmers in this study generally conduct livestock counts on a weekly basis in the Free State Province and on a monthly or quarterly basis on the more extensive sheep farming enterprises in the Northern Cape Province. Nevertheless, the application provides a means for reporting such losses, with at least the farm name and location, and an estimated date, which may otherwise have remained unreported. However, according to Clack (2018), farmers report only a relatively small number of stock theft to authorities. Regarding suspected predation incidents, there is currently no system in South Africa requiring the reporting of predation losses, except in the Western Cape. The details of such incidents may be reported as quantitative data using the “Notes” screen of the application (Fig. 5.2.1).

In the case of “verified” predation incidents (signs of predation are present), the predator species likely responsible for predation is recorded. Knowing which predators are most likely to kill livestock or specific wildlife species, as well as when and where predation risk is highest, is a vital step in effectively reducing losses (Jaeger, 2004).

The “Livestock & wildlife losses” mobile device application was designed to record all aspects of the predation incident (Fig 5.2.2; Part 2 of the 2014-Questionnaire, Appendix 1). The application allows for photographs (Fig. 5.3) to be taken of the scene where predation took place. Predation management specialists can use such photographic records to confirm losses due to predation, or assist farmers in the identification of the predator species responsible for damage in cases where the farmer has difficulty identifying it. Such photographs are also useful for predation management training courses as practical examples when training participants to positively identify predator species responsible for the damage.

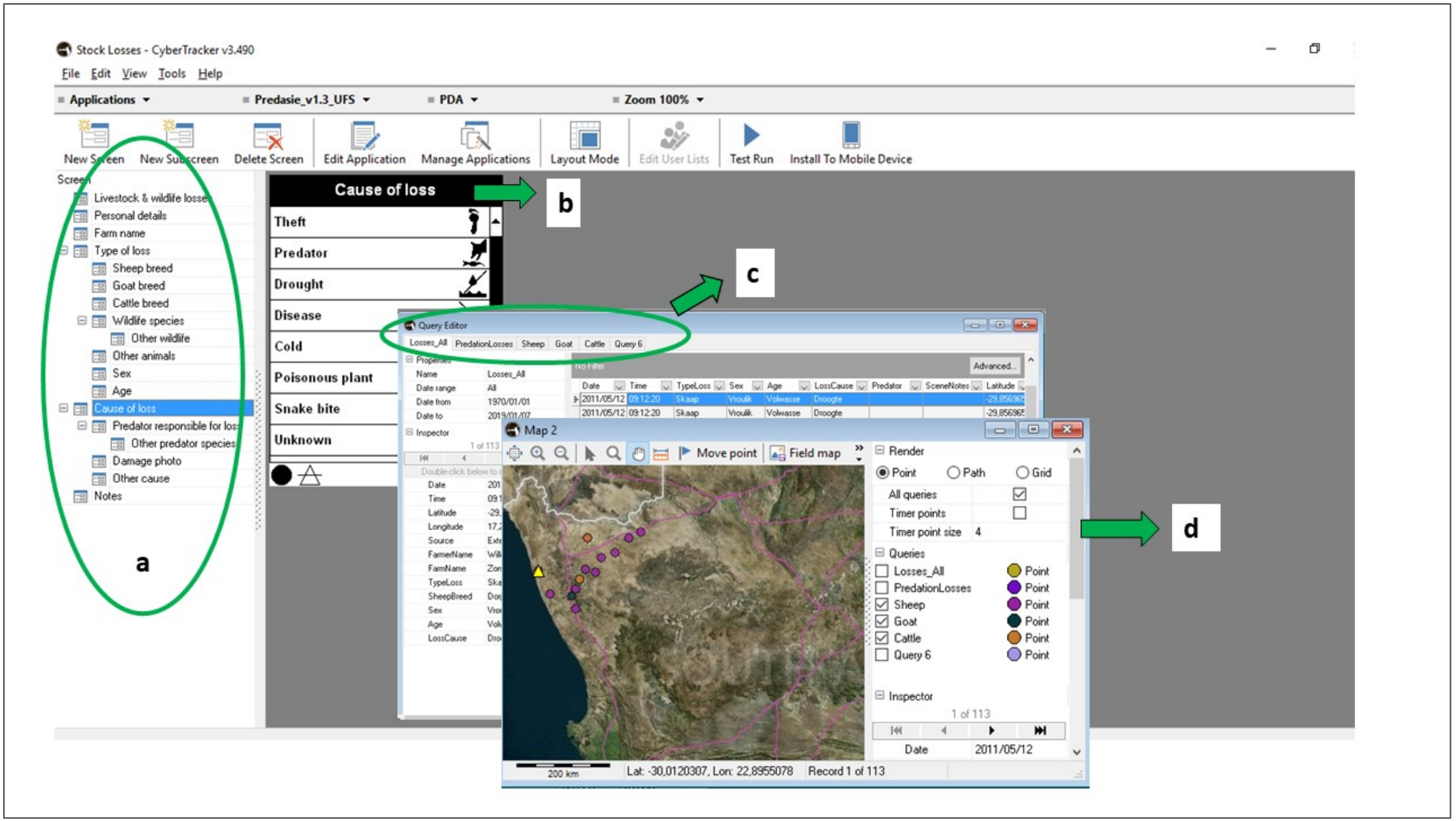

Figure 5.1 The mobile device application for collecting data on livestock and wildlife losses, showing examples of (a) the type of data to be collected; (b) the screens as displayed on the mobile device; and (c) the queries created to filter out specific subsets of data; and (d) preliminary maps to view the different sets of data.

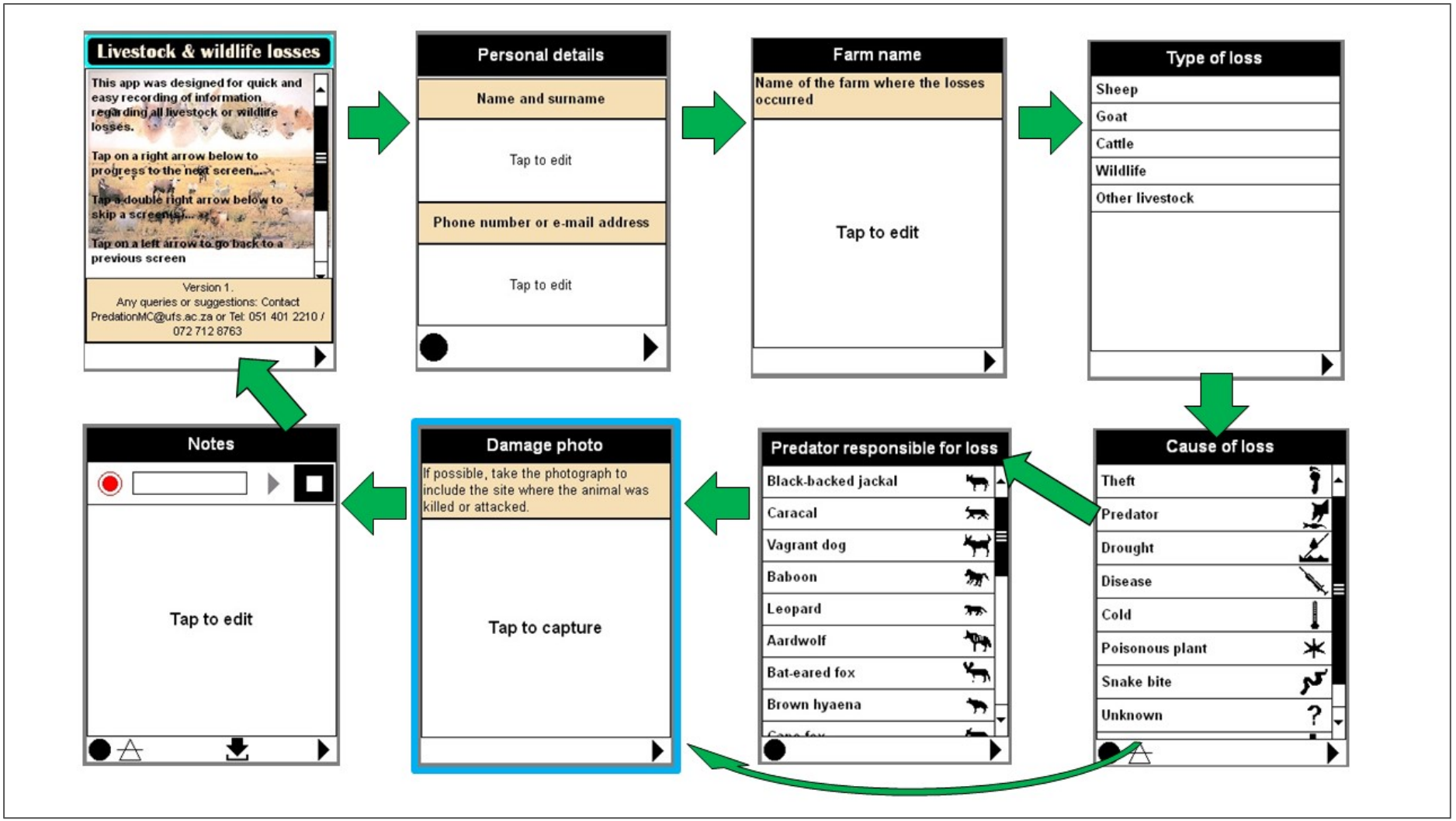

Figure 5.2.1 Livestock & wildlife losses application - Sequence of screens for collecting basic data regarding losses experienced on livestock farms or wildlife ranches. A photograph can be taken of each predation incident (optional – screen outlined in blue).

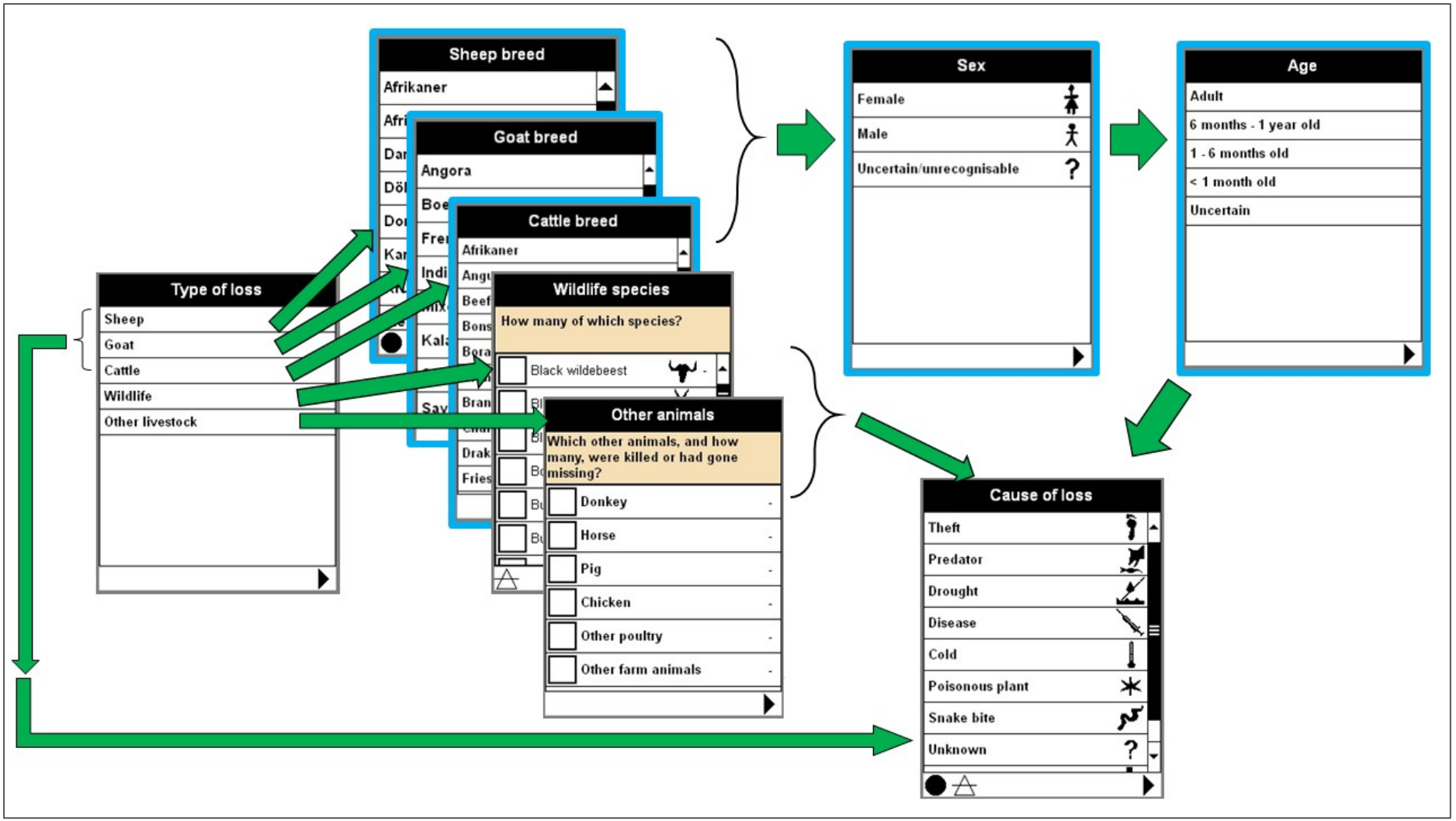

Figure 5.2.2 Livestock & wildlife losses application - Sequence of screens for collecting detailed data regarding losses experienced on livestock farms or wildlife ranches. Additional optional information is collected with screens outlined in blue.

Figure 5.3 Example of a photograph taken of a predation incident. In this case, a lamb was killed by domestic dogs.

Detailed data, such as the livestock breed or wildlife species, the sex and age classes of animals killed by predators (Fig. 5.2.2), may provide insights into the relative vulnerability of different livestock breeds (including sex and age classes) or wildlife species to different predator species (Beinart, 1998), as well as the losses relative to the size and composition of the herd or flock in question and the economic implications of these losses (Mertens & Promberger, 2001; Van Niekerk, 2010). For example, the number and age of prey consumed per attack can be used in studies describing the characteristics of predation by a particular predator species (Stahl *et al*., 2001) to assist in the development of practical predation management strategies.

When combined with data regarding the physical and managerial characteristics of a farm (collected by means of the 2014-Questionnaire), the degree to which environmental conditions, husbandry practices, and predator management programmes affect the loss patterns can be assessed (Knowlton *et al*., 1999). It will also provide an indication of additional financial expenses associated with particular non-lethal measures in efforts to protect livestock and wildlife from predators.

More detailed recording, however, requires more time, while not all farmers may be willing to record losses with the same amount of detail. Giving the user a choice in terms of the amount of detail to include in the reporting process will invariably give rise to more detailed vs only basic data sets for analysis. Nevertheless, the data from either set will be useful. Recording only the basic information requires less than one minute

per incident, while an incident with all the detail provided for in the application can be recorded within 1.5 minutes.

Qualitative data may provide valuable insights into specific predation situations, or as experienced by particular individuals or groupings (Section 4.3). The “Livestock & wildlife losses” application was designed to collect such information (Fig. 5.2.1). A particularly useful feature of the applications designed in this study is that such qualitative data may be recorded making use of a built-in voice recorder, saving time and effort when out in the field.

5.2 Reporting results

The “Livestock & wildlife losses” application was tested using the data collected by means of questionnaires (Chapter 4), importing predation data from MS Excel into the “Livestock & wildlife losses” database created with the CyberTracker software. The data were then imported into ArcGIS 10.6 to produce a map illustrating the extent and distribution of predation (Fig. 5.4), as reported by Groups A to D. However, the low overall and item response from Groups A to D prevented further analysis of the data such as seasonal distribution and intensity of livestock predation or other predation patterns in GIS.

Although various research projects in South Africa have focussed on human-predator conflict (Du Plessis, 2013; Thorn *et al*., 2012; 2013; Constant *et al*., 2015; Minnie *et al*., 2016), little is still known about the underlying patterns. Brand (1989) postulated that the extent of damage in some areas may be ascribed to the inability of farmers or hunters to eliminate the predators responsible for livestock losses, which may have led to the inefficiency or improper application of available control methods. The methods described by Brand (1989) as the most common methods applied in an inefficient or improper manner in areas with high predation losses were also the methods most commonly used in areas with highest predation losses in the present study. However, the amount and nature of the data supplied by Groups A to D precluded further investigation into cause-and-effect of predation and predation management practices.

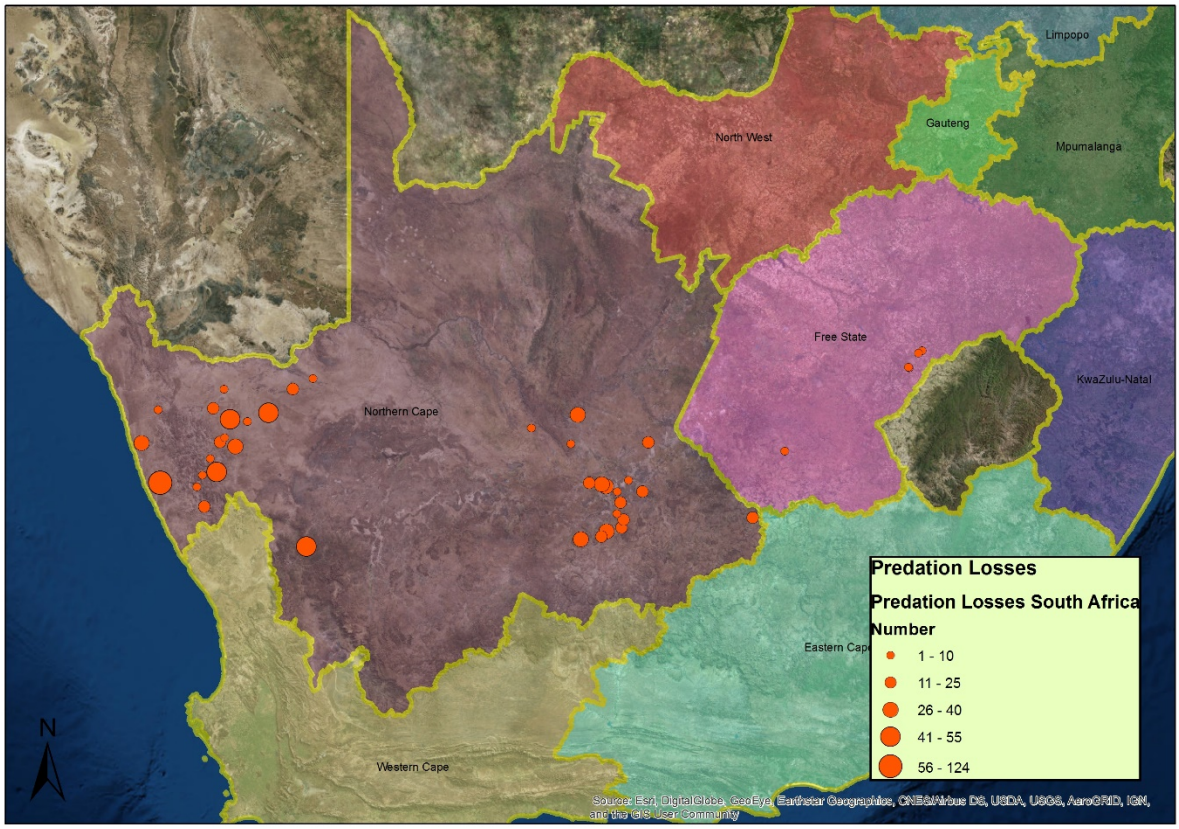

Figure 5.4 The extent and distribution of livestock losses due to different predator species, as reported by Groups A (Namaqualand District, Northern Cape Province), B (Pixley ka Seme District, Northern Cape Province), C (Thabo Mofutsanyane District, Free State Province) and D (Xhariep District, Free State Province) from 2011 to 2014.

An explicit understanding of human-predator conflict is necessary for devising mitigation strategies (Dar *et al*., 2009; Du Plessis *et al*., 2018). Digital data collection applications provide for collecting large sets of geo-referenced data, which reveal spatio-temporal patterns of predation (Dar *et al.*, 2009). Maps generated from the spatio-temporal data may allow for predation hotspots to be tracked in near real-time. Evaluating trends and patterns in predation, may also elucidate seasonal variation in the cost and benefit of predation management strategies (Thorn *et al*., 2012), allowing decision-makers to allocate financial resources and technical aid to areas where it is most needed at the time (Treves *et al.*, 2004; Miller *et al.*, 2015; Michael Bodenchuk, 2018, personal communication). Focusing time and resources in the form of technical assistance and extension efforts on areas with high predation losses may prove cost-effective (Treves *et al*., 2004).

Variables such as those collected in the present study (making use of a digital data collection tool such as the Livestock & wildlife losses application and Part 1 of the 2014-Questionnaire to collect data on farm characteristics and management practices), may provide insights into the complexity of human-predator conflict (Dar *et al.*, 2009). Supplementing such data with information on human activity or population densities, land uses and vegetation types is useful for generating predation risk models (Treves *et al*., 2004; Behdarvand *et al.*, 2014). Predation risk models are increasingly being used as management tools in devising human-predator mitigation strategies (Zarco-Gonzales *et al*., 2013; Davie *et al.*, 2014; Miller *et al.*, 2015) by serving as an early warning system.

Predicting predation risk and determining the underlying drivers of conflict situations will aid wildlife managers, scientists, farmers and ranchers in defining management zones to adapt mitigation strategies, implement targeted prevention strategies and provide guidelines to reduce conflicts (Treves *et al*., 2004; Kolowski & Holekamp, 2006; Behdarvand *et al.*, 2014; Constant *et al.,* 2015; Miller *et al.*, 2015). Furthermore, identifying effective management practices may facilitate policymaking and action planning within government departments to mitigate the conflicts (Behdarvand *et al.*, 2014).

Predation risk maps are also useful tools to communicate predation risk patterns to stakeholders from different educational and cultural backgrounds (Miller *et al.*, 2015). Supplying feedback to farmers is crucial for maintaining their cooperation in supplying predation data. Maps and reports can be generated for each farmer, supplying summaries or results in terms of predation patterns on his farm(s). Alternatively, maps and reports may be generated for the larger group (for example, a farmers' association or producers' organisation), which will provide insights into patterns and trends occurring in the area or during specific timeframes. The impact of predation management on predation trends on particular farms vs neighbouring farms may be illustrated.

Depending on the preference of the farmer or group, reports may be generated on a monthly or seasonal basis. Reporting back to a group may illustrate the distribution of predation in the area covered by farms within the group. Reporting on the predation

patterns or general trends of predation may be done in relation to surface area, climatic conditions, physical characteristics of the area (topography or vegetation), land-use type, stocking rates, predation management practices (husbandry, non-lethal and lethal predation management techniques).

With the use of mobile device applications, results that are readily accessible by the stakeholder groups which supply predation management data may serve as incentive for stakeholders to continue supplying data (Decker *et al.*, 2002). According to Drill (2013), an increased level of stewardship among participants allows them to gain a better understanding of the data they supply, thereby empowering them to improve their management practices. However, this process will still need to form part of a broader predation management programme or system to ensure a continued supply of data. Thereby government agencies involved in issues surrounding predation management may be informed about the most pressing concerns in an area or among a particular group of stakeholders and engage in concerted efforts to find solutions.

6 Mobile device application: reporting predator control

The hunt reports studied by Gunter (2008) were designed ostensibly for recording hunts in response to livestock losses reported by farmers, to record the number of predators killed and the distances travelled by each hunter so that he could be officially reimbursed accordingly. The performance of the hunt clubs was evaluated based on the data contained in the hunt reports, and hunt clubs were subsidised accordingly. The records on the report forms therefore reflected only the predator control operations in reaction to livestock losses reported to the hunt club by farmers. The hunt reports did not reflect predator control operations conducted by farmers themselves.

Assessing the efficacy of specific conflict management strategies on single farms is important because topography, habitat, climate and management practices may differ considerably between geographic areas, between neighbouring farms (Brand, 1993; Du Plessis, 2013), and even between different sites on the same farm (Stahl *et al.*, 2002). Increasing the selectivity of control methods such that the damage-causing individuals are removed (Grafton, 1965; Pringle & Pringle, 1979; Stuart, 1981; Rowe-Rowe, 1986; Avenant, 1993; Andelt *et al.*, 1999; De Wet, 2006) requires a thorough knowledge of the species of predator involved in each predation incident (Bothma, 1971a; Strauss, 2009). Obtaining the knowledge required to achieve selective control requires keeping accurate records of all predators removed from a property in control operations, including information on sex, weight, age, condition and farm name (Swanepoel, 2008).

Because predator control is conducted not only in reaction to damage, but as a measure to prevent predation on certain farms, and because many farmers make use of the services of specialist predator hunters, a separate application was designed for recording predator control activities. In so doing, specialist predator hunters could also be provided with an application to record their activities.

6.1 Designing the tool for reporting predator control to address knowledge gaps

Recording control of damage-causing animals as it is conducted provides accurate numbers for animals removed during control operations and may provide comparative estimations of population densities (Gier, 1957). It eliminates recall bias (Connolly, 1978; Decker *et al.*, 2002) and may also reduce social desirability bias associated with interviews (Decker *et al.*, 2002; Thorn *et al.*, 2013). In addition, it provides a timeframe to relate predator control to reported predation incidents and vice versa.

Due to the controversial nature of lethal predation management strategies, evaluation of specific predator control methods is essential (Herfindal *et al.,* 2005). The efficiency of different control methods may depend on the physical and climatic characteristics of an area and may vary according to season (Stuart, 1982; Avenant, 1993).

Therefore, studying the efficacy of the different control methods requires large samples (geographically as well as large numbers of participants) and extended periods to enable scientists and wildlife managers to assess the efficacy of a particular method over a variety of different conditions in the field (Skinner & Todd, 1990). Furthermore, research must provide knowledge into the reasons for a particular method being effective or ineffective (Shivik, 2004).

The problem of livestock predation persists in many areas and is reported to be increasing (Avenant & Du Plessis, 2008). This phenomenon has been ascribed to indiscriminate hunting disrupting the social behaviour and reproduction of these animals. Disturbance by human activity has been reported to alter habitat preference and spatial utilisation, activity patterns, social organisation, feeding and reproduction of these animals (Grobler, 1981; Stuart, 1981; Moolman, 1986; Stuart & Hickman, 1991; Avenant, 1993; Kaunda, 2000; Kaunda, 2001). Therefore, it is also important to investigate the effects of high hunting pressure vs low hunting pressure on subsequent predation by different predator species.

The “Predator Control” application (Fig. 6.1) was designed to provide livestock farmers, wildlife ranchers and specialist predator hunters (including government

officials) with a tool to record predator control activities in the field. The tool presents an opportunity to incorporate local knowledge into the Management Information System (MIS) to mitigate human-predator conflicts in South Africa.

Recording the date and location of each predator control operation allows for better evaluation of short-term effectiveness of predator control by providing insights as to whether specific incidents can be related to the predation previously experienced in a particular area. Bothma (1971a) and Stuart (1984) suggested that one of the most important factors in the successful removal of a damage-causing predator is that the response to the damage should be swift. The application automatically records the date, time and GPS coordinates for each predator control activity logged, providing an accurate and efficient method for collecting predation management data and investigating its relation to predation data collected with the “Livestock & wildlife losses” application.

While data examined by Gunter (2008) suggested that swift response from specialist predator hunters generally prevented further losses for two months on most farms, and up to two years on other farms, Gunter (2008) cautioned against drawing conclusions from such limited data sets. Furthermore, in the data sets considered by Gunter (2008), hunters employed by the subsidised hunt clubs at times reported that “predators were under control” since farmers reported fewer livestock losses during those times. However, the focus on cause-and-effect of predator control may not be enough – on farm level as well as on a regional or provincial level – to explain the decreases in reported livestock losses. Therefore, supplementing the data collected using the Predator control Application with additional farm and predation management data collected from livestock farmers and wildlife ranchers using Part 1 of the 2014-Questionnaire (**Appendix 1**) is gain a better understanding of the dynamics of different combinations (lethal and non-lethal) of predation management strategies.

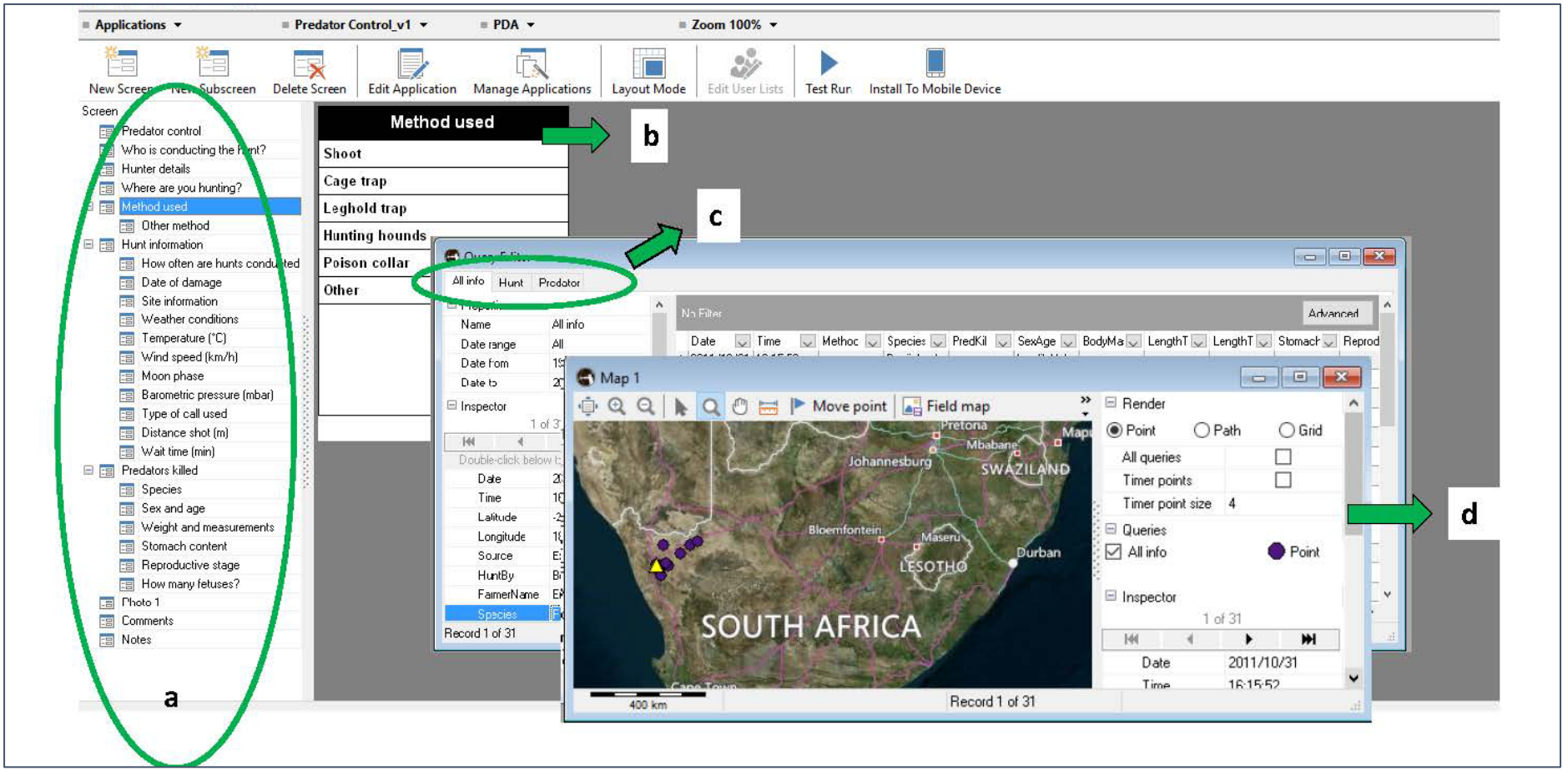

Figure 6.1 The “Predator control” application for collecting data on predator control activities, showing examples of (a) the type of data to be collected; (b) the screens as displayed on the mobile device; and (c) the queries created to filter out specific subsets of data; and (d) preliminary maps to view the different sets of data.

Brand (1989) emphasised that, while predator control appears to reduce predator density effectively in the short term, the long-term effects on populations are unknown. Today, farmers and specialist predator hunters in South Africa commonly practice preventive predator control to reduce predator populations, particularly before the onset of the lambing seasons. Although many maintain that it is an effective way of reducing predation during the time of year when livestock is most at risk, the long-term effectiveness of this approach is still unknown. In the USA, Wagner & Conover (1999) reported a 50% reduction in livestock losses when coyote control was conducted as preventive measure, compared to pastures where no preventive measures were implemented. In addition, where conflicts did occur in pastures where preventive control was conducted, these conflicts required less human intervention.

Collecting predation management data over extended periods provides the opportunity to monitor long-term efficacy of methods. The digital data collection tool developed for collecting data on predator control, combined with Part 1 of the 2014-Questionnaire are useful for collecting data on predation management, but collecting data over extended periods will only be possible through longitudinal engagement with farmers, predation management specialists and authorities.

Bigalke & Rowe-Rowe (1969) noted increased difficulty in controlling black-backed jackal over time. They also reported that increased hunting effort appeared to have little effect on black-backed jackal populations, and speculated that it may only take off the annual population increase. Bingham & Purchase (2002) also alluded to the ability of black-backed jackal populations to recover rapidly following population crashes. Similar findings have been reported for caracal (Marker & Dickman, 2005).

Similar to the “Livestock & wildlife losses” application (Chapter 5), the user (livestock farmer, wildlife rancher or specialist predator hunter) has the option of recording only the basic information necessary for research into predator control (Fig. 6.2.1), or more detailed data (Figs. 6.2.2 and 6.2.3). The sequence of screens that becomes available when the user selects the “Shoot” predator control option contains detail regarding prevailing environmental conditions, type of call used, the time elapsed until a predator was shot or the hunter moved on to the next site (where no predators were shot), and the distance over which the predator was shot. However, recording these data is

optional, since this method of predator control often requires the person conducting the hunt to swiftly move to the next site in order to find predators reacting to the calls, not allowing time to record such detail.

Recording only the basic information requires less than one minute per control operation, while recording an incident with all the detail provided for in the application can be recorded within 1 minute if the control operation was unsuccessful and within 2.5 minutes per predator killed during a call-and shoot control operation.

The application was designed to record detail on the type of control, i.e. if control was conducted to reduce predator populations, in reaction to damage, or routinely (Fig. 6.2.1). In cases where control is conducted in reaction to damage, the date of the damage (estimated date, in cases where livestock went missing or where carcasses are relatively old) is recorded. Where control is reported as being conducted on a routine basis, a screen becomes available to record the frequency with which these hunts are conducted (Fig. 6.2.2). Long-term data on the nature of predator control operations may provide insights into their effectiveness in reducing subsequent predation.

Recording the sex of the predators killed may provide insights into the sex ratios of animals killed during specific times of the year, or with the use of particular control methods (See Section 6.3). Behavioural differences between males and females of a predator species during certain phases of their annual life-cycle and hunting pressure may influence the sex ratios of predators caught or killed in control operations (Stuart, 1982; Brand, 1989). Bigalke & Rowe-Rowe (1969) found, for example, that more black-backed jackal males were killed during the whelping season, when females spend more time tending to their young.

Studying the extent and distribution of predation by different predator species, and the subsequent control of predators may provide insights into the interactions between predator species in an area. Furthermore, since moon phase, wind and rain affect the activities and behaviour of different predator species (Brand, 1989; Avenant, 1993), studying the influence of these factors on the behaviour of a particular species may

assist in formulating more effective, practical strategies to remove damage-causing individuals of that species (Kolowski & Holekamp, 2006).

Data on the body mass and measurements of the predators removed during control operations are an indication of the condition of the predators, providing insights into the conditions governing the health of the predators, ultimately influencing reproduction (Minnie, 2015). Recording the number of foetuses carried by pregnant females may also aid in investigating whether compensatory breeding in response to persecution can be substantiated (Du Plessis, 2013).

Including age groups in the data sets may identify age groups more or less susceptible to particular control methods or during specific phases of their annual life-cycle (De Waal, 2017b). According to Brand (1993), control of black-backed jackal during October to December results in the removal of animals under the age of one year, since this is the time during which young black-backed jackals disperse. Identifying age groups also enable scientists to evaluate the status of a predator population and determine whether it is increasing, static or decreasing to aid in formulating management principles (Lombaard, 1970). Provision was made in the “Predator control” application to take photographs of the teeth of the predators removed during a control operation (Fig. 6.3), which may give a fairly accurate indication of the age class of the predator removed (Lombaard, 1970).

Figure 6.3 Photographs taken using the “Predator control” application to report predator control activities.

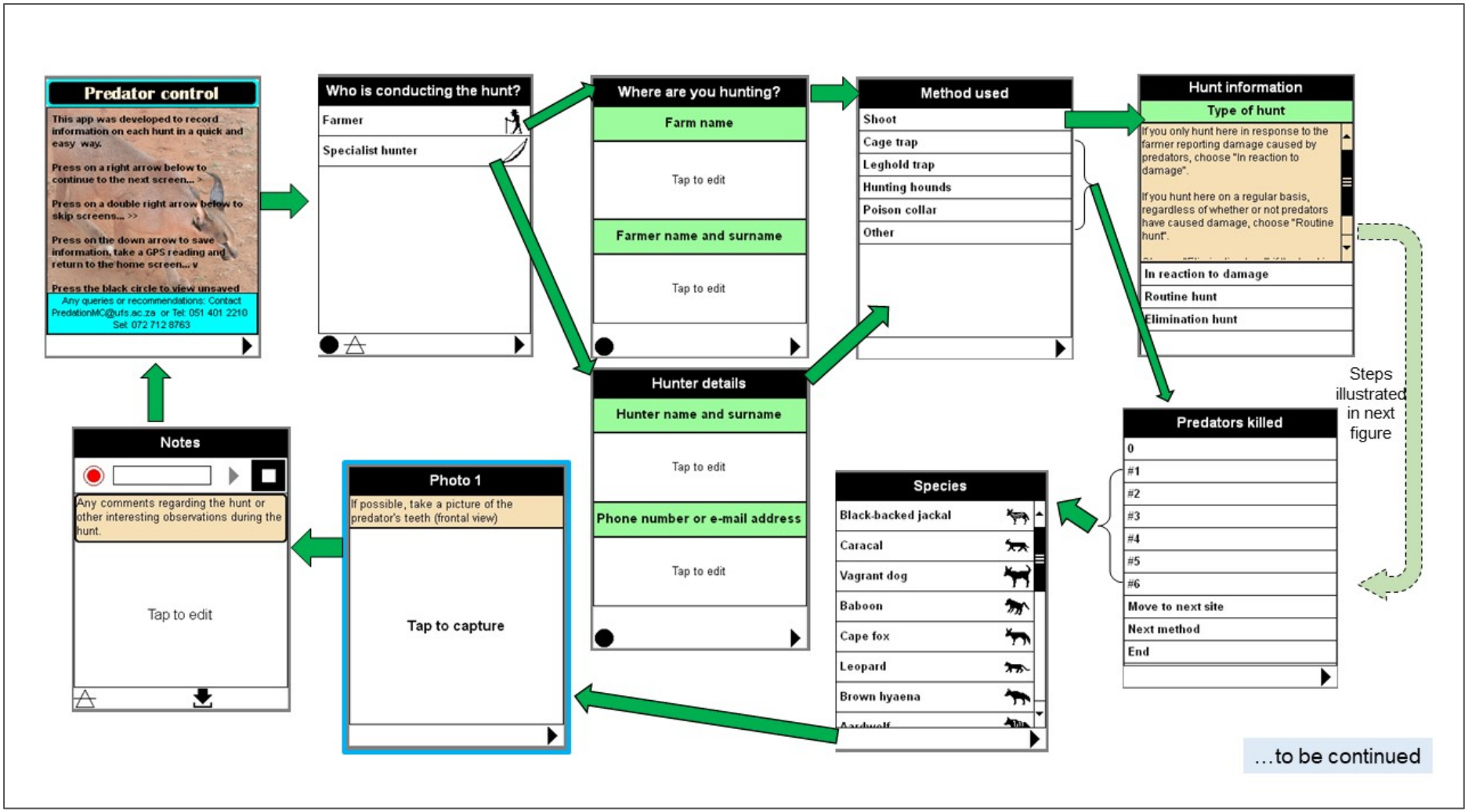

Figure 6.2.1 The “Predator control” application - Sequence of screens to record only the basic information regarding predator control operations conducted on a farm, covering all the different control methods. Screens outlined in blue are optional and can be skipped should the user prefer not to record such detail. Notes may be recorded by typing or by recording a voice note.

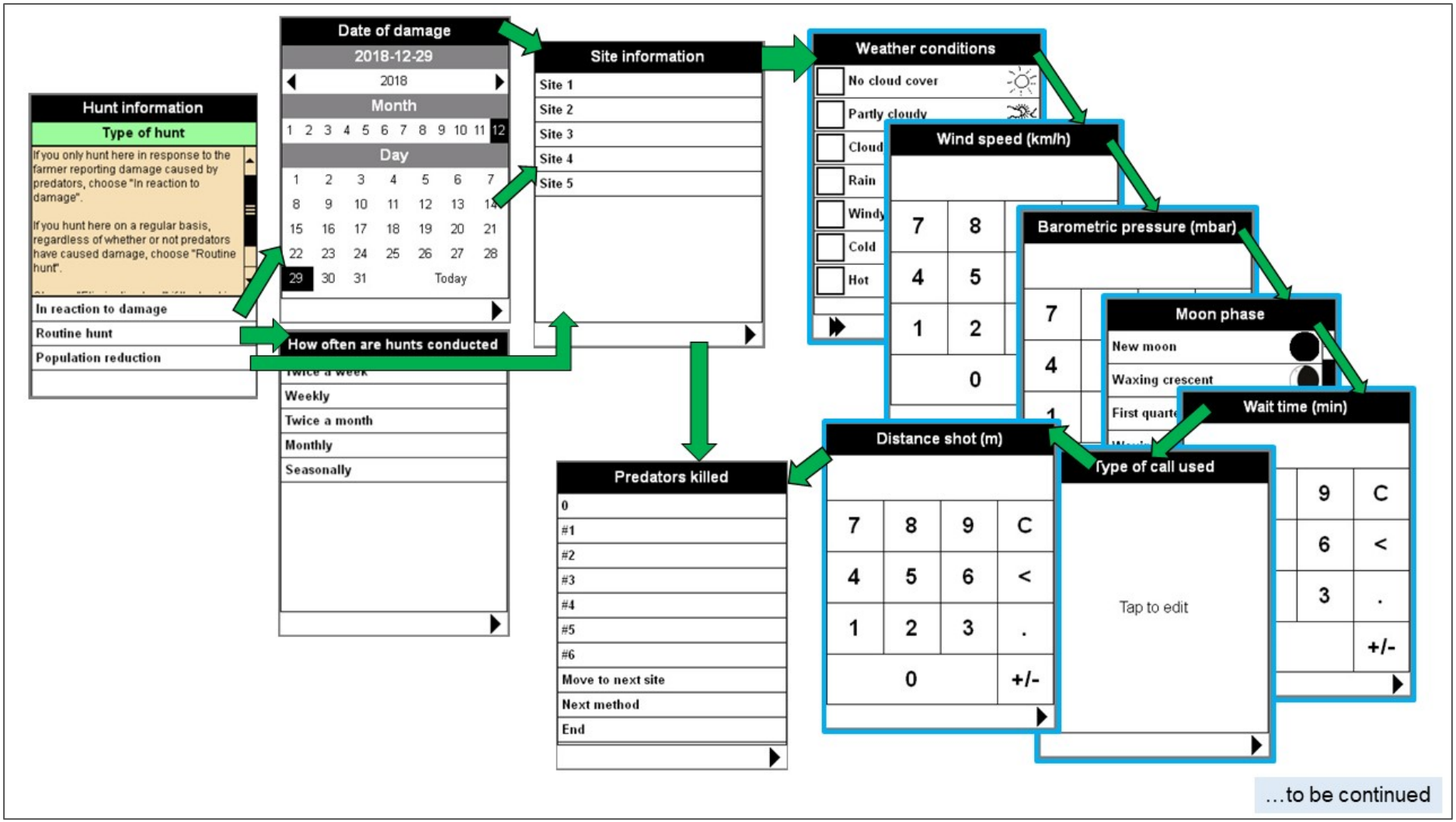

Figure 6.2.2 The “Predator control” application - Sequence of screens to record detailed information regarding “Call-and-shoot” control operations. Screens outlined in blue are optional and can be skipped should the user prefer not to record such detail.

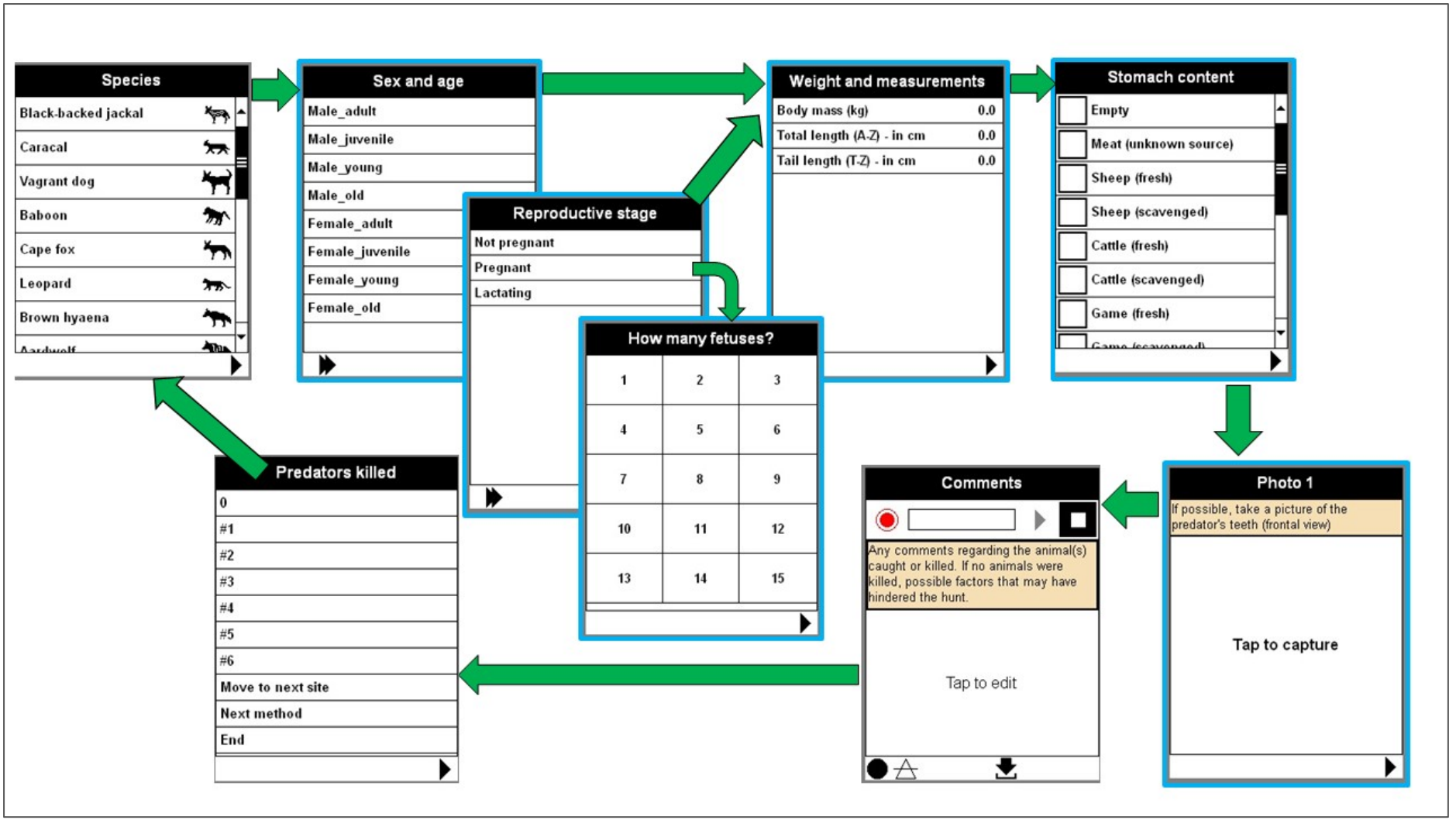

Figure 6.2.3 The “Predator control” application - Sequence of screens to record detailed information regarding animals removed during control operations. Screens outlined in blue are optional and can be skipped should the user prefer not to record such detail. Comments may be recorded by typing or by recording a voice note.

Under certain circumstances, recording the stomach content of predators killed in control operations give an indication of the diet of predators (Bothma, 1971a; b; Minnie, 2015) in particular areas and during a particular time of year. Grafton (1965) alluded to the importance of diet in studying the ecology of predators, as well as determining the extent and causes of predation and for devising control methods. If control in response to livestock predation is swift, it may confirm whether the predator was responsible for killing livestock or wildlife as reported with the “Livestock & wildlife losses” application. According to Bowland & Bowland (1991), depending on the quantity eaten by the predator, prey remains are passed through the gut of a black-backed jackal within 24 hours. It is also possible to distinguish whether the prey had been scavenged or whether it was a fresh kill (Grafton, 1965). However, it should be noted that checking stomach contents may not be worthwhile in situations where predators were captured in traps (when they are likely to void their stomachs), or during the time of year when female black-backed jackals provide for pups by regurgitating their food. Thus, considering the sex and age classes may also be useful in deciding whether or not to check for stomach contents.

6.2 Testing the tool in the field

It was decided to test acceptance of the concept of mobile device applications for use in coordinated predation management among specialist predator hunters because the hunters are known for being more inclined to make use of technology to aid in predator control.

In preliminary discussions with members of a local hunters’ association, mention was made of the use of mobile device applications during predator control operations, and how the data collected in this manner could benefit the hunters’ association and individual members. The concept was well-received, and further discussions entailed from which types of data members would benefit. The “Predator control” application was then modified to include the collection of data of particular interest to specialist predator hunters (Fig. 6.2.2).

Both the “Livestock & wildlife losses” and “Predator control” applications were presented to a group of specialist predator hunters during a meeting at the University

of the Free State in October 2018, because a number of the hunters were also farmers. They were requested to test these applications in the field. Each of the 21 hunters who completed questionnaires regarding the use of mobile device application supplied to them during the meeting, were of the opinion that mobile device applications of this nature could be useful in improving predation management.

Of the 21 hunters, nine volunteered to test one or both of the applications. However, only three of the hunters out of this group tested the “Predator control” application during the period October to December 2018, recording data from their hunting activities. This group of specialist predator hunters was designated Group E. The data returned by Group E are illustrated in Figure 6.5. Results from the data are discussed in Section 6.3. As was the case with Group B in this study (Section 4.2.4), it was later learned that some individuals may have influenced others in the group to refrain from cooperating with the PMiC.

The application was designed to include details of particular interest to specialist predator hunters who make use of the “call-and-shoot” method (namely: weather conditions; moon phase; the type of recording played to lure the predator; the duration of each hunt; and the distance over which the predator was shot). However, the call-and-shoot method of predator control is also one in which the hunters often do not necessarily have the time to record each incident as it is completed. Therefore, modification to this application is necessary to make it more user-friendly for particularly call-and-shoot operators, so as not to disrupt the hunt in cases where predators are especially wary. During the 3-month testing period, valuable feedback was from hunters received from the hunters for consideration in the process of modifying the application to make it more user-friendly.

6.3 Reporting results

6.3.1 Groups A to D

The “Predator Control” application was tested using the data collected with the questionnaires (Chapter 4) by importing predation data into the database created with the CyberTracker software. The data were then imported into ArcGIS 10.6 to produce

a map illustrating the extent and distribution of predator control (Fig. 6.4), as reported by Groups A to D.

The low overall and item response prevented further analysis of the data such as the effects of landscape characteristics and climatic conditions on predator control, or other patterns relating to predator control in the GIS. The data collected from farmers in this study were useful in showing only the location (coordinates of homestead provided by farmers or taken from *ca* the middle of the farm) and number of predators removed during control operations (Fig. 6.4).

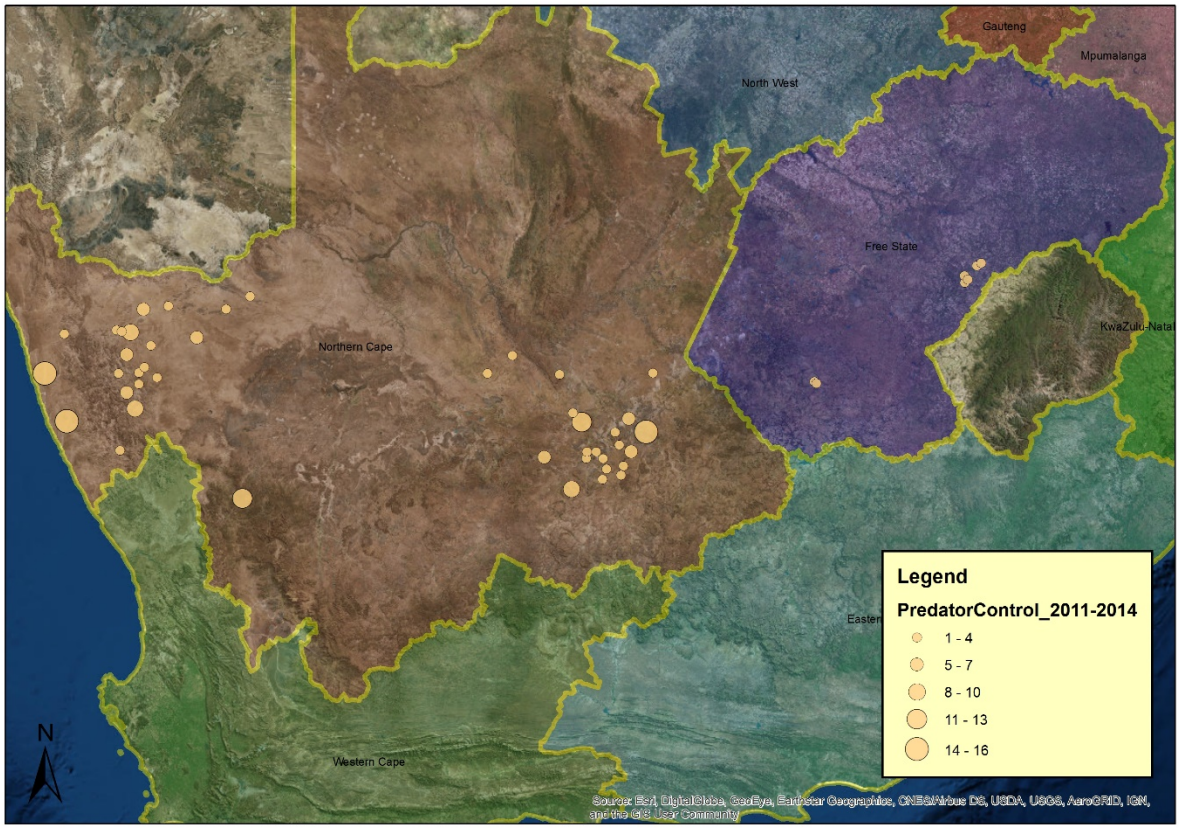

Figure 6.4 The extent and distribution of predator control activities reported by farmers in Groups A (Namaqualand District, Northern Cape Province), B (Pixley ka Seme District, Northern Cape Province), C (Thabo Mofutsanyane District, Free State Province) and D (Xhariep District, Free State Province) from 2011 to 2014.

6.3.2 Group E

Testing the application in the field, the hunters from Group E illustrated the value of such a tool for collecting accurate, detailed data in real-time for predation management

research. The data entered into the application by each hunter appeared in the central ArcGIS database and was accessible for analysis almost instantly. Due to the small data set received during October to December 2018, however, ArcGIS 10.6 instead of ArcGIS Online was used to create a map illustrating the number and distribution of predators removed during control operations (Fig. 6.5).

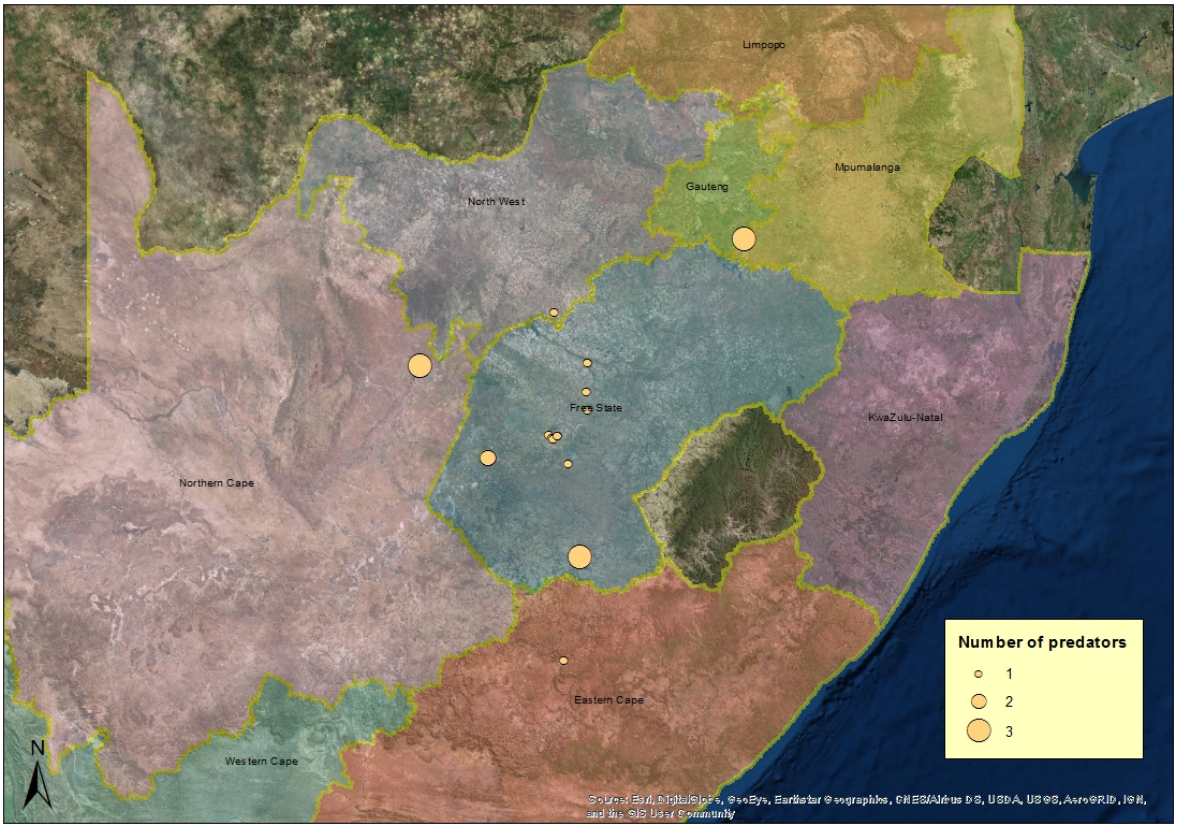

Figure 6.5 The number and distribution of predators killed during control operations conducted by hunters in Group E.

The reaction of the specialist predator hunters to livestock predation reported by farmers was reportedly swift. The hunters all made use of the “call-and-shoot” method. Of the total (n = 14) hunts conducted in reaction to predation losses, seven were reportedly conducted on the same day the damage was reported to the hunter, four were conducted the day after the damage was reported, and three were conducted two days after the damage was reported. Stomach contents were not reported for four of the predators killed in reaction to damage. Of the remaining nine predators checked for stomach contents, four were reported to have empty stomachs, one reportedly had carrion (sheep), and two had contents which the hunter was unable to identify. The

stomach contents of the remaining predator were meat (unidentified prey species), grass and other plant material. Due to the small sample size, however, further investigation was not conducted to determine the effectiveness of the “call-and-shoot” method in removing the predators responsible for predation on livestock (Grafton, 1965).

A total of 27 predators were killed by hunters in Group E during the period October to December 2018, of which black-backed jackal was the main predator species (70.4% - Table 6.1). Caracal comprised 14.8% of the predators killed in control operations, baboons 11.1%, and Cape fox 3.7% (Table 6.1). Of the total predators killed, 14 (51.9%) were killed in reaction to damage reported by farmers, 9 (33.3%) were killed in routine hunts, and 4 (14.8%) were killed in hunts conducted as preventive measure to reduce predator populations. The predators killed during population reduction hunts were all black-backed jackals, and all were females.

Table 6.1 The number and species of predators killed in control operations conducted by Group E.

Hunter	Black-backed jackal	Caracal	Baboon	Cape fox	Total predators per hunter
Hunter 1	2	0	0	0	2
Hunter 2	7	1	0	1	9
Hunter 3	10	3	3	0	16

Table 6.2 Sex and age classes of the different predator species killed in predator control operations conducted by Group E.

Predator species	Male, Young	Male, Adult	Female, Juvenile	Female, Adult	Female, Old	Not Specified
Black-backed jackal	2	4	3	7	3	0
Caracal	0	0	0	2	2	0
Baboon	0	2	0	0	0	1
Cape fox	0	0	0	1	0	0

Of the total black-backed jackals killed in control operations, more females (68.4%) were killed than males (31.6%; Table 6.2). These sex ratios may be explained by the females starting to become more active in foraging for food during this part of the year (October to December) as pups start eating meat (Bothma, 1971b). Conversely, it may

be attributed to the control method used and or other factors which may also contribute to the skewed sex ratios.

Juvenile females were killed only during December 2018 – the time of year when black-backed jackals disperse from their natal dens (Brand, 1993). Two male pups were killed, one early in November 2018 and one in mid-December 2018 – the time of year when pups emerge from dens (Ferguson *et al.*, 1983). Due to the small sample size, however, no generalisations could be made in terms of age and sex ratios of predators killed during hunts.

All hunts, except in the case of controlling baboons, were conducted at night. A noteworthy observation from the data is that the control of caracal appeared to be related to moon phase. The four caracals killed in control operations were all killed during full-moon. Communicating these results to hunters from this group, some commented that they had observed this trend during their experience as specialist predator hunters. Caracal activity being affected by moon phase seems contradictory to the findings of Moolman (1986) and Avenant & Nel (1998).

In contrast, Brand (1989) suggested that caracal activity is affected by moon phase, while Minnie *et al*. (2018) suggested that caracal activity patterns are context-dependent. Therefore, larger data sets are important to provide more reliable information and thus, insights into specific conditions in which caracal will be successfully controlled. This type of information is invaluable in developing practical predation management strategies for farmers, wildlife ranchers and predation management specialists (including hunters and government officials) to implement in the field.

The results presented in this chapter highlight the value that mobile applications such as the one designed for this study may add to research regarding predation management in South Africa. Since standardised methods for data collection has been lacking in predation studies in general (globally), the technology used here may also have application further afield (studies conducted in other continents, on species indigenous to those countries).

It is important to reiterate here that the collection of larger, continuous data sets will require the methodology developed in this study to form part of an overarching system of coordinated predation management. Chapter 7 describes how this methodology and the information obtained with this approach may be integrated into a system of coordinated predation management.

7 Integrating the mobile device applications into the Management Information System

The previous chapters described past approaches to predation management in South Africa, the current state of predation management and the role of research; particularly methods used to date to provide scientific basis for informing predation management. Conventional approaches to predation management research are becoming more challenging due to limited resources, the scale at which individual projects are able to operate and lack of coordination. The result is that research rarely succeeds in making significant contributions to "the bigger picture" regarding predation management.

The methodology proposed in this study was designed for collecting large, complex sets of accurate data (Bearzi & Saylan, 2008). It was developed to provide a means for collecting standardised data to address the inconsistency in research (Graham *et al.*, 2005; Du Plessis *et al*., 2015), facilitate data analysis (Sangay & Vernes, 2008) and inform coordinated predation management. However, for such a tool to make meaningful contributions to predation management, it must form part of a larger, coordinated system of predation management.

A Management Information System (MIS) plays a fundamental role in driving official human-predator conflict management programmes by facilitating co-operation between different stakeholders and government institutions to develop, evaluate and improve management strategies (Connolly, 1995; Lowney *et al.*, 1997; Messmer, 2009). Such methodology is grossly lacking in South Africa where predation management is almost entirely in the hands of livestock farmers, wildlife ranchers and private operators (specialist predator hunters) (Avenant & Du Plessis, 2008; De Waal, 2009; 2017b; Bergman *et al*., 2013). Similar to the USDA-APHIS WS scenario, this collection of data should be part of a comprehensive system of coordinated predation management, based around an indispensable MIS.

7.1 The role of digital data collection applications in science-based management

All types of data collection methods have advantages and disadvantages. Recent advances in available technology in the form of digital data collection methods reduces the time, effort and costs associated with collecting and processing field data (Riley *et al.*, 2002) compared with conventional methods such as interviews and questionnaire surveys (Connolly, 1978; Knowlton *et al.*, 1999). Various processes are required to engage communities to achieve acceptable and sustainable management programmes (Decker *et al.*, 2002). Therefore, the methodology proposed in this study comprises the collection of quantitative and qualitative data, as well as longitudinal engagement with farmers (Du Plessis, 2013; Thorn *et al.,* 2013; Constant *et al.*, 2015). A multi-method approach to predation management research provides a means to gather as much information on the different aspects of human-predator conflict on farm level as is necessary to develop mitigation strategies tailored to a specific situation (Knowlton, 1999; Inskip & Zimmerman, 2009; Strauss, 2009).

Digital data collection applications are now widely used in environmental and wildlife management programs (Will *et al.*, 2014). Similar to the applications designed during the course of this study, the desktop application used by US Wildlife Services officials to capture data during predation management operations in the field was designed to collect all information that may be needed for thorough investigation. Although it may not be necessary to collect specific data for a particular project, the official can collect it with the application if such data is required for a study (Michael Bodenchuk, 2018, personal communication).

Many commercial properties are bordered by National Parks, Provincial Reserves, and other types of state-owned land (e.g. military, agricultural, etc.), human settlements (cities and towns) and communal areas. The nature of human-predator conflict varies between the different land-use types. Little to no predator control is conducted on state-owned land, as well as other types of farming enterprises such as cattle and crop farms and private game reserves, and are thus perceived by sheep farmers as breeding grounds for predators such as the black-backed jackal (Beinart, 1998). Collecting standardised data will allow investigation into the spatial and temporal scale

of conflict for different damage-causing predator species and different land-use types. Visualisation of such data provides the scope to gain more knowledge into predator-prey relationships as well as predator-predator relationships than would be possible with conventional research methodologies.

7.1.1 Visualising data collected on farm-level to aid in formulating management strategies

A subset of the data collected with the aid of questionnaires is presented to illustrate the value of farm-level data to managers in formulating predation management strategies in a particular area. This information comprises the data received from three farmers in Group A (Namaqualand District, Northern Cape Province) with the highest overall as well as item response (i.e. the farmers who supplied the most detailed set of continuous data).

Table 7.1 Sheep losses due to predation, as reported by three farmers from Group A during the period May 2011 – February 2012.

Farmer ID	Farm name	Predators responsible for damage								Total
		Black-backed jackal	Caracal	Baboon	Brown hyaena	Vagrant dog	Caracal/ Baboon	Cape fox	Eagle	
NC_00004	1a	12	6	5	3	3	0	1	0	30
NC_00012	2a	2	18	0	0	0	1	0	1	30
	2b	8	0	0	0	0	0	0	0	
NC_00017	3a	2	0	0	0	0	0	0	0	9
	3b	7	0	0	0	0	0	0	0	

There was a striking difference in the predation experienced on each of these farms (Table 7.1, Fig. 7.1), which may, at least in part, be ascribed to differences in management practices employed by the farmers. Due to the small data set, the effects of topography and other environmental factors on the number of predation losses and the predator species involved were not investigated. Predation was generally highest among adult sheep and lambs in the 1 – 6 month age class (Table 7.2). The three farmers all reported hunting (shooting) predators themselves on their farms, in combination with jackal-proof fencing.

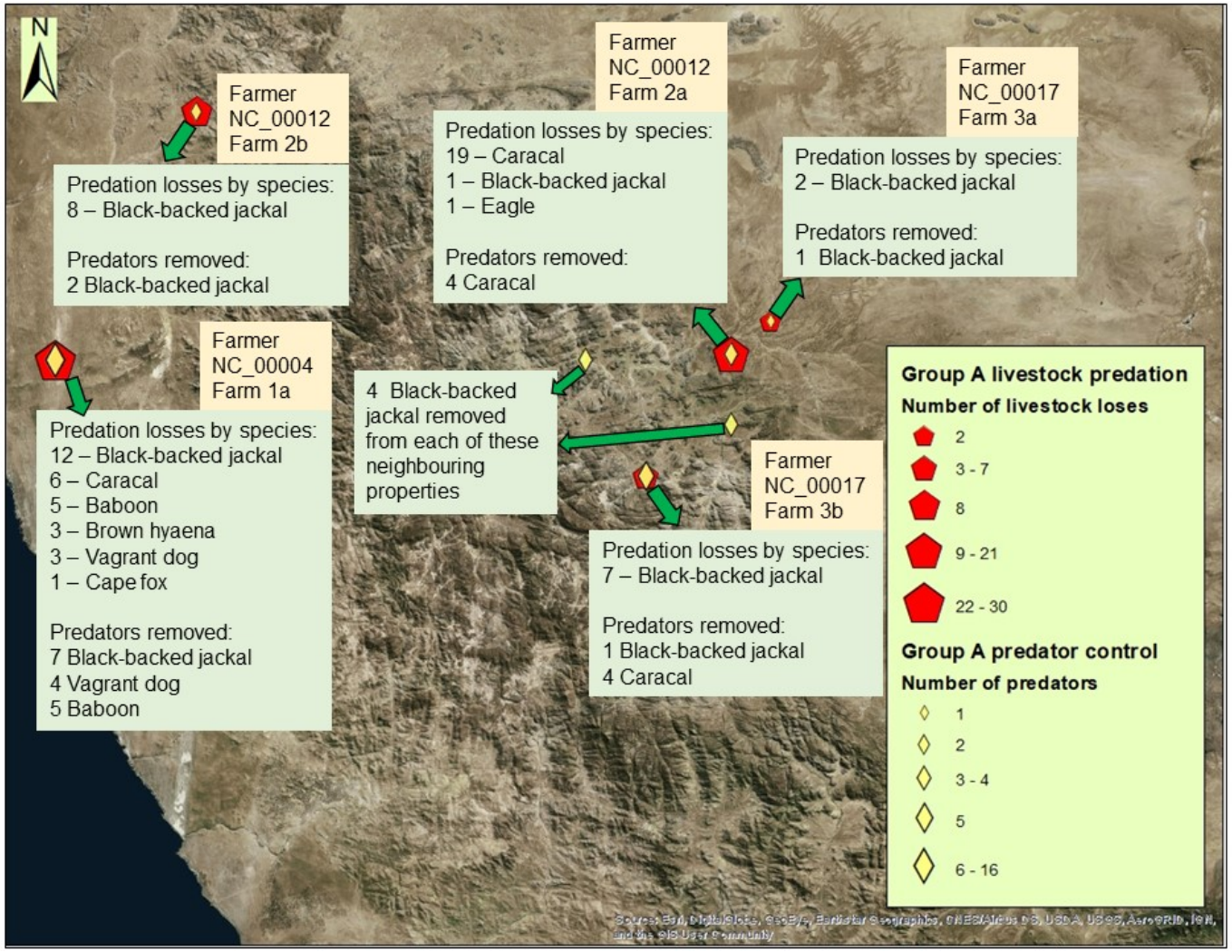

Figure 7.1 Visualisation of data supplied from May 2011 to February 2012 by the three farmers in Group A.

Table 7.2 Age classes of sheep killed by predators, as reported by three farmers from Group A during the period May 2011 – February 2012.

Farmer ID	< 1 mo	1 - 6 mo	6 mo - 1 y	Lamb*	Adult
NC_00004	0	0	11	3	16
NC_00012	3	12	0	0	15
NC_00017	0	9	0	0	0

* Age class of the lambs were not specified

Of the three farmers, the losses incurred by farmer NC_00004 were the most for a single farm, and these losses were caused by various predator species during the period May to December 2011 (Table 7.1, Fig. 7.1). Sixteen adult ewes and 14 lambs were killed by predators, which translates to 0.6% of his total flock and 2.8% of his annual increase. Lambs were killed mainly by baboons and black-backed jackals. This farmer reported no losses among lambs younger than six months. This may be attributed to the use of small pastures for lambing during his June and September lambing seasons, while ewes lamb in the veld only during his November – December lambing season. Adult sheep were killed mainly by caracals, followed by brown hyaenas, vagrant dogs and black-backed jackals. This farmer's approach also differed from those of the other two in that he reported (a) counting his sheep quarterly instead of weekly, and (b) making use of a specialist predator hunter, while the others conducted predator control themselves using foothold traps and cage traps to control predators.

Predator control can be summarised as follows from the questionnaires received from farmer NC_00004:

- The brown hyaena and Cape fox that caused damage in May 2011 were not found.
- Following the damage caused by black-backed jackals in June 2011, two black-backed jackals were removed in June and one in July. However, damage due to black-backed jackal was reported again in August, after which two black-backed jackals were removed. The next record of sheep losses due to black-backed jackal was in December 2011 and as a result, one black-backed jackal was removed during this month.

- One vagrant dog was removed in June and two in August 2011 after causing damage during these months.
- After damage was reportedly caused by baboons in June 2011, four baboons were removed. Another baboon was removed in December 2011.
- The only sheep loss due to caracal was reported in July 2011, but no caracal was found.

Farmer NC_00012 lost 30 sheep (3% of total flock) during the period May to November 2011, but these losses were spread over two farms (Table 7.1; Fig. 7.1). Losses comprised 15 adult ewes and 15 lambs (0.72% of his annual increase). Caracal was the main predator responsible for damage and killed mostly adult sheep. Caracals and black-backed jackals killed most lambs, mainly lambs in the 1 - 6 months age class. This farmer, as well as NC_00017, reportedly used electric fencing. Farmer NC_00012 was the only farmer out of the three who reported regular handling of sheep. Although regular handling of sheep has been implied as one of the husbandry practices effective in preventing predation, the losses incurred by NC_00012 was much higher than for NC_00017. The availability of long-term (longitudinal) data and or data from surrounding areas (e.g. land use type, and predation losses and predator control data from neighbouring farms) may illuminate reasons for elevated losses on this farm despite regular handling of livestock in such cases.

From the questionnaires submitted by farmer NC_00012, predator control can be summarised as follows:

- Damage caused by caracal was reported for May, July, September, October and November 2011. Two caracals were subsequently removed in May, three in September and another in November. The stomach content of the caracals reportedly consisted of sheep.
- In July and August 2011 black-backed jackals reportedly started to cause damage, and six black-backed jackals were subsequently reported to have been removed between August and October 2011.

Farmer NC_00017 lost 10 lambs in the 1 – 6 month age class and eight one-month old lambs from May 2011 to February 2012. Black-backed jackals were reportedly

responsible for all the losses, which occurred during the farmer's lambing season. The losses represent 2% of the farmer's total flock and 8% of his annual increase. This farmer reported the use of hounds as additional predator control measure.

Predator control as reported by farmer NC_00017 can be summarised as:

- One black-backed jackal was removed in June 2011, in reaction to the damage caused during this month.
- Although the damage reported in August 2011 was presumed to be caused by black-backed jackal, four caracals were removed during the following month.
- No further damage was reported in any of the following questionnaires (October 2011 to February 2012). Although it may appear that the predation problem may have been (at least temporarily) resolved, the absence of livestock losses during this period may also be ascribed to reduced energy demands of black-backed jackals due to this species being reproductively inactive during this time (Bernard & Stuart, 1992).

Although the data collected in this study from Groups A to D were too scant to create a clear overall picture of the predation situation over the total area covered, it provided an indication of how the impact of predation, the physical and managerial characteristics of farms, as well as specific predation management strategies, varied considerably not only between the different groups, but also between farmers in a group. The data described in this section illustrate the potential of this level of detailed data, and was useful to illustrate the statement by Henderson & Spaeth (1980) that:
"It is impossible to examine one livestock management factor individually, while holding all other factors constant. Also, differing levels of management can influence not only predation losses, but other predisposing factors or sources of loss such as starvation, disease, parasitism, and weather. Then too, certain locales may traditionally have high predation losses, for reasons other than management, which are difficult or impossible to quantify. At least in some instances, a 'good' livestock manager may have higher predation losses than a 'poor' manager".

Larger data sets are necessary to improve our understanding of predation patterns over time and to identify underlying factors that play a role in such patterns (Mitchell

et al., 2004; Du Plessis, 2013) as well as the scale of predation (Van Niekerk, 2010) and factors influencing predator control/predation management. Specific advantages of data collected in this manner include:

- Collecting large data sets, which may improve the deductions that can be made. Detailed information covering extensive areas of South Africa may allow for comparisons to be made between regions, production enterprises with similar characteristics, or investigation into the efficacy of management strategies on, for example, district level. Furthermore, while some management strategies may result in an immediate decrease in predation, effects may not be lasting (Strauss, 2009). Adjustments in an ecosystem as a result of changing a particular facet of that ecosystem may occur over two to three decades (Bothma 2002 as cited by Strauss, 2009). It is therefore important to collect longitudinal data to study and monitor the success and efficiency of management strategies in the long term.
- Complete time series data will allow for detailed investigation into cause-and-effect of predation management and possible knock-on effects, as well as analysis of trends with regard to predation and management strategies employed.
- Examining predation patterns during a specific time of year (e.g. in relation to the time when predators disperse, provide for young, mating seasons, etc.).
- In combination with results from other research such as studies investigating predator ecology (including reproductive, dietary, behavioural studies and prey availability), predation management data will allow wildlife managers to clearly define predation management problems (Stoddart *et al*., 2001; Jaeger, 2004).

A better understanding of the extent, distribution, determinants and patterns of human-predator conflicts may result in better prediction (Kliskey & Byrom, 2004; Chapter 5) and may play a vital role in informing management, methods and ecology, human dimensions, and policy and planning (Treves *et al*., 2004; Tulloch *et al.*, 2013). However, further testing of the mobile device applications is necessary in different settings (e.g. commercial farms vs. wildlife ranches and communal areas) to address potential trade-offs between data quality and quantity, standardising sampling methods, quantification of sampling effort, and mismatches in skills and expectations between data collectors and data users (Tulloch *et al.,* 2013).

7.1.2 Shortcomings of the proposed methodology

The data collected using the digital data collection tool and the questionnaires designed for collecting supplemental data on individual farms can provide valuable insights into the effectiveness of different predation management methods. However, refinement of the methodology is still needed for recording additional detail which may be of significance for further investigation into specific aspects of predation management on farm level.

The following may be considered:

- Include timeframes and sequence in which predation management methods are used. The questionnaire (2014-Questionnaire) for supplementing the data collected with the applications (Livestock and wildlife losses application, Predator control application) makes provision for recording which lethal and non-lethal methods are used in combination as predation management strategy on a farm. In the case of methods such as cage traps and foothold traps, however, modifications may be necessary to record detail such as the dates on which traps are set or rebaited to allow investigation into the effectiveness of such methods (Gunter, 2008). Such detail may serve as foundation for refining the methods in question (Brand, 1989).
- Improve user-friendliness of the Predator control application for use by farmers or hunters making use of the “call-and-shoot” method of predator control.
- Provide an option to distinguish between “suspected” predation incidents (where uncertainty exists as to whether a predator was indeed responsible for the damage) and “verified” predation incidents. Currently, such details may be recorded as qualitative data using the “Comments” or “Notes” screens of the Livestock and wildlife losses application.
- A clear quality control plan must be developed before the applications developed in this study can be made available for wider use (Drill, 2013). The potential for errors and bias associated with the methodology proposed here is still unknown (Dickenson *et al.*, 2010). Therefore, the data should also be tested for reliability (Drill, 2013).

- The Livestock and wildlife losses application was designed to allow the user to take a single photograph of the scene where carcasses were discovered to verify whether the livestock or wildlife had been predated upon. However, detail such as killing and feeding location on the carcass (including canine puncture marks or talon marks), tooth marks on bones, predator tracks or scat (McKenzie, 1990; Verzuh *et al.*, 2018) may be obscured in such a photograph. The initial application did make provision for recording such detail to guide the user in the identification of the responsible predator, but at the expense of the user-friendliness of the application. Additional screens may be added to the application to allow for more photographic recording of such evidence, but avoid causing "participant fatigue" (Drill, 2013), which may discourage the use of the application.
- Although digital data collection methods have the potential to make data collection easier and more attractive, facilitating use among users with no scientific background, a formal framework needs to be developed according to which use among stakeholders must be determined.
- Methodology should include assessments of the perceptions of the various stakeholders. A separate questionnaire may be designed to obtain feedback and suggestions from attendees of regular contact sessions.

7.2 A Management Information System and coordinated predation management

7.2.1 Coordinated action

The current lack of institutional memory and coordination with regard to predation management has resulted in fragmented efforts among various stakeholder groupings and role-players to mitigate human-predator conflicts in South Africa (Chapter 2). Vast amounts of time, energy and resources are ploughed into individual initiatives and programmes. While some of these may be effective at a local level, the impact of predation on food security and the livelihoods of individual farmers remains an issue of national concern. Similarly, lack of coordination of research has hampered progress in terms of predation management in South Africa. Furthermore, research is being conducted through several tertiary and research institutions, with little evidence of important research findings and recommendations being considered and implemented

on a large scale. For predation management research to truly make meaningful contributions to human-predator conflict mitigation in South Africa, integration into a formal system is of utmost importance.

Similar to the previously active systems of predation management in South Africa, and the co-operative predation management programmes employed by the USDA-APHIS-WS, future efforts at coordinated predation management in South Africa should strive to integrate non-lethal, lethal or compensatory (when feasible) human-predator conflict mitigation measures, research, monitoring and evaluation, and training and extension (Dorrance, 1983; Brand, 1989). Because predator species range across property and political boundaries, predation management programmes should be conducted on a regional level (Dorrance, 1983; Lawson, 1989; Brand, 1993; Andries Strauss, 2018 personal communication), as well as on provincial and national levels, necessitating partnerships between governmental and non-governmental organisations to achieve relevant geographic scope (Shelton, 2004; Dickinson *et al.,* 2010).

Shared responsibility among wildlife managers, individuals, and communities through local government (Decker *et al.*, 2002) allows for stakeholders to be directly involved in various stages of management, from the identification of problems to implementing and evaluating management strategies (Chase *et al.*, 2000). Where such co-management approaches have been implemented, it resulted in a more supportive, educated, and involved public (Chase *et al.*, 2000). But if the responsibility of wildlife management rests solely on either the government or the property owner, the non-participant may make unreasonable demands or become disinterested (Dorrance, 1983). Although requiring substantial time, effort and resources, this approach holds the promise of greater satisfaction with management if judiciously implemented and supervised (Gier, 1957; Chase *et al.*, 2000). An MIS is central to developing, implementing, supervising and developing these processes (Fig. 7.2).

An example of a system currently in place, which has been successful in terms of cooperation between farmers, specialist predator hunters and local government to achieve effective predation management, is that practiced in the Western Cape Province (CapeNature, 2013). Only by means of such a system, the methodology proposed in this study can be successfully used in the collection of predation

management data. Data is collected from farmers and specialist predator hunters with regard to predation management. However, the research component (monitoring & evaluation) of this system is grossly lacking due to CapeNature not having the capacity to use the data for research (Jaco van Deventer, 2017 personal communication), emphasising the need for collaboration between government departments (agricultural as well as conservation) and tertiary or research institutions in a province.

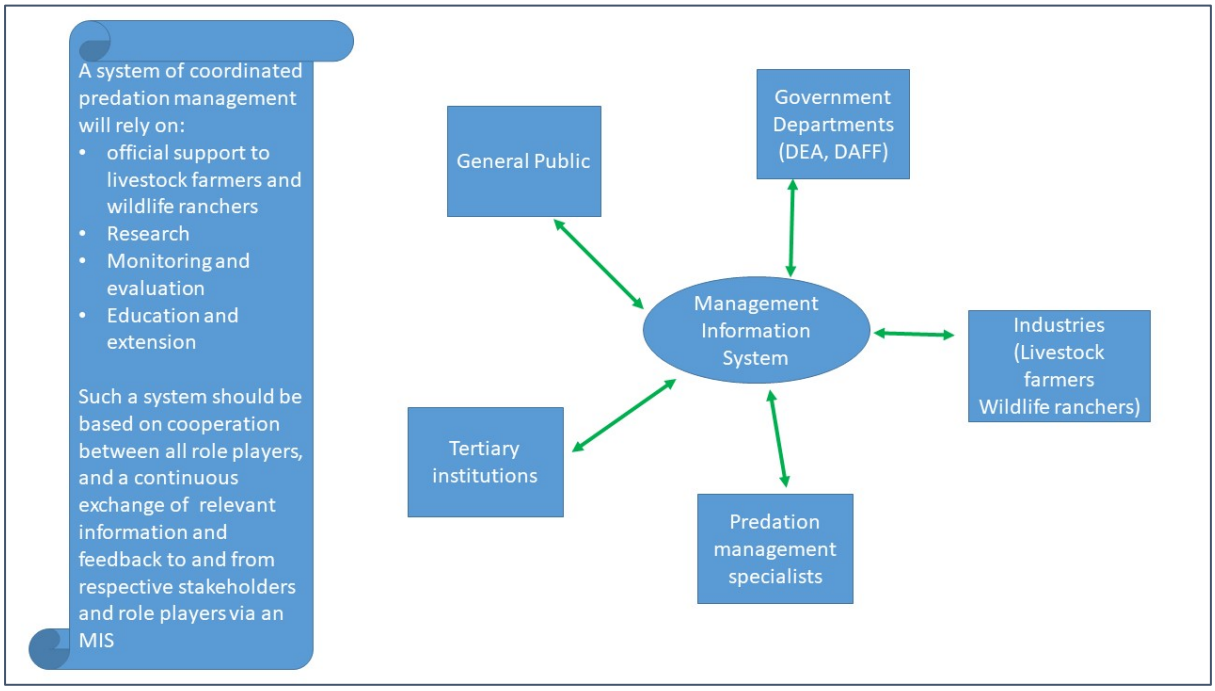

Figure 7.2 The role of a Management Information System (consisting of various databases) in coordinated predation management.

The MIS described in Chapters 2 and 3 may serve as administrative backbone to promote coordinated action across disciplines and stakeholder groupings. Building on existing information contained in the MIS may allow for strategic planning to identify and prioritise suitable management approaches, adapt management strategies as new control methods become available, and evaluate the efficiency of specific approaches (Lowney *et al.*, 1997). A predation management programme should be sufficiently flexible over time to adapt to knowledge and experience gained by wildlife managers during the course of the programme, yet suitable for different situations (Brand, 1993; Avenant *et al.*, 2009; Du Plessis *et al.*, 2018). This process is known as "adaptive management". A lack of flexibility may cause the parties directly affected by or involved in predation management to feel excluded, which may reduce the number

of alternative solutions that can be developed and even exacerbate conflict (Redpath *et al.*, 2013). Because it is near-impossible to conduct predation management research under experimental conditions (Henderson & Spaeth, 1980), it is important that research be conducted as part of adaptive management.

An adaptive management process should not rely too heavily on linear models or disregard non-scientific knowledge, and should incorporate policy processes that may support cooperation among various stakeholders (Vold & Buffett, 2008). An adaptive management cycle is described by Vold & Buffett (2008) as consisting of the following steps:

1. Setting objectives and targets. Clear objectives and sampling design is essential to understand and communicate the true benefits of predation management data to the public and policy-makers, and to avoid the use of data for the wrong purposes, wasting resources, or inadequate datasets that fail to inform decisions (Tulloch *et al.,* 2013).
2. Planning actions based on existing objectives and targets, technology and inventory. Coordination among scientists and programme managers will be critical to ensure that data will be comparable and that a project in a particular area does not deviate from the collective targets and priorities (Decker *et al.*, 2002).
3. Implementing actions based on these plans. Protocols should be clear and instructions should be easy to follow (Drill, 2013).
4. Monitoring to determine the effects of these actions, including socio-ecological and environmental effects (Kolowski & Holekamp, 2006).
5. Evaluating the actions implemented to assess which results lead to new knowledge. Problems and the effectiveness of mitigation strategies must be reviewed regularly (Balfour & Kerley, 2018).
6. Adjusting targets or plans where necessary to better meet objectives; and
7. Incorporating results into future management decisions.

7.2.2 Research, training and extension

While livestock predation is the most commonly reported aspect of human-wildlife conflict, the greatest disparity exists in methods used to collect data and report results

relating to these conflicts (Inskip & Zimmerman, 2009). This may result in livestock predation numbers being generated that differ for the same period and area (Brand, 1989). The results of studies are therefore not easily comparable due to the varied nature of factors that play a role in predation and predation management (Gese, 2005; Inskip & Zimmerman, 2009; Du Plessis, 2013). Furthermore, the lack of a reliable or consistent framework for human-predator conflict assessment and management has also contributed to sparse and inconsistent data available for different conflicts. This information deficit may, in turn, limit identification of key factors and detecting patterns, especially in the South African context (Graham *et al.*, 2005; Du Plessis, 2013).

Assessing factors that influence predation on livestock farms and wildlife ranches is difficult because of the interdependence between husbandry, environmental factors and the behavioural ecology of predators (Stahl *et al.,* 2002). This calls for concerted efforts by livestock farmers, wildlife ranchers, scientists, wildlife managers, government and the public to set research priorities, use resources more effectively and produce more focused research outputs (Kolowski & Holekamp, 2006; Du Plessis *et al.*, 2015). Reducing the current disparity in conflict reporting methods may facilitate investigation into patterns and trends of human-predator conflict, thereby enabling practitioners to address conflict more effectively (Till, 1992; Inskip & Zimmerman, 2009).

The MIS created by the PMiC, specifically the databases regarding predation management research, specialists and scientists (Sections 2.2.1 and 3.1), may be useful in facilitating coordination in research efforts. Drawing on examples from the human sciences may also be useful in terms of modifying the databases contained in the MIS to promote coordinated research. Examples include:

(a) Research Networking – a database created in response to a need for networking and cooperation. It contains biographical profiles of individual human science researchers in South Africa, including their fields of interest and areas of specialisation.
(b) TALK Worldwide – a database containing the details of the most important local and international human sciences conferences and meetings. It is future-oriented and contains entries five years ahead.

Communication of research results and data gaps is important in a system of coordinated predation management and can be achieved through extension programmes (Stuart, 1981; Brand, 1993). Coordination of extension activities on a national level is important (Gipson & Reidinger, 1994) to provide stakeholders with objective, scientific assessments of the actual degree of the problem, to provide particular stakeholders, such as special-interest groups with a factual basis for appraising controversial issues (Dorrance, 1983), and attempt to provide reasonable solutions for it (Lowney *et al.*, 1997; Shivik & Fagerstone, 2007). To achieve this, involvement from government (DEFF and DARDLR) is important. Extension officers from the respective departments may communicate new developments in predation management to livestock farmers and wildlife ranchers through existing extension programmes.

Protecting livestock against predators is as important for animal production as disease prevention, breeding and feeding programmes, etc. therefore, extension programmes regarding preventive predation management should be a function of DARDLR. However, predation management is not a topic covered in current extension programmes run by DARDLR. Facilitating training for extension officers and the provision of extension materials (Section 3.1.3) will be an important function of an MIS to ensure communication of research outcomes to farmers.

Besides allocation of resources to predation “hotspots”, an MIS may assist government in facilitating training of government officials and specialist predator hunters to provide livestock farmers and wildlife ranchers with technical support. There is currently no indication whether the skills and knowledge possessed by DEFF officials who provide predation management services to farmers will be transferred to a “next generation” of officials. The few individuals currently operating as predation management specialists have been practicing predation management since the time when the coordinated systems of predation management were in place. Continued government involvement is crucial to prevent the loss of invaluable institutional memory and expertise when these individuals are no longer in the employ of DEFF.

Research outcomes may also be communicated to participants or the public by means of regular reports and feedback to associated groups (Sections 5.4 and 6.3),

newsletters or making it available on a website (Tulloch *et al.,* 2013; Banda, 2016) such as the one created by the PMiC for disseminating information pertaining to predation management. ArcGIS Online, which hosts the database to which the CyberTracker applications created during this study sync the data collected, also provides platforms on which research results can be shared with participants in the form of “web apps”.

7.2.3 Using existing information to inform mitigation strategies

Predation management research should be a continuing effort (Gier, 1957; Shelton, 2004). Monitoring the situation requires longitudinal data to determine the dynamics of predation and identify trends or patterns in predation. Monitoring provides the learning necessary for continuous improvement. Modelling and mapping the data to identify locations or specific periods during which predation risk is highest and predict where and when predation peaks may occur, will aid in formulating long-term, efficient and biologically sound management strategies. In addition, documented monitoring of outcomes of management strategies provides common ground for stakeholders and development of stakeholders’ understanding of the system, reducing tensions between stakeholders (Redpath *et al.*, 2013; Balfour & Kerley, 2018).

Improvement of a predation management programme can only be evaluated objectively with a database (Dorrance, 1983). Reports generated through the use of an MIS have enhanced the credibility of the USDA APHIS Wildlife Services animal damage control programme (Accord, 1999). Since monitoring and evaluation of predation management techniques contribute to the sustainability of a predation management programme (Inskip & Zimmerman, 2009), it is crucial for a predation management programme to include objective, scheduled evaluations (Dorrance, 1983).

7.2.3.1 Digital data collection applications for incorporating current data into an MIS

A digital data collection tool that forms part of a coordinated system of predation management may provide for longitudinal data to be collected on the extent and costs of predation and methods currently in use to alleviate stock losses. Within such a system, the methodology developed here could be used to establish a national

database, giving rise to large datasets. Similar to the database used in the US, subsets of the data can be filtered and made available to scientists with the necessary permissions (David Bergman, 2018 personal communication) to maximise the use of the data (Tulloch *et al.,* 2013), while ensuring that confidentiality of data is not compromised. For example, a subset containing data on stomach contents can be made available for studies on the diet of a predator species.

Connolly (1978) suggested that the lack of a coordinated system and government support may lead to increased losses, greater impact on non-target species and control being less safe and humane as it is practiced by more non-professionals. Since little is known about the environmental impacts of a lack of a programme (Shwiff & Bodenchuk, 2004), the data gathered in this way may provide valuable insights into the situation as currently experienced on properties, and provide the basis to compare the efficiency of management strategies before and after implementation of a coordinated programme. Prevention of environmental damage is an immense benefit provided by an effective predation management programme (Shwiff & Bodenchuk, 2004). Collecting data on a real-time basis with a digital data collection tool, may allow for resources to be allocated to target where and when predation management issues are most intense to reduce the costs resulting from conflicts (Inskip & Zimmerman, 2009, Michael Bodenchuk, 2018 personal communication).

The methodology proposed in this study (Chapters 4, 5 and 6) is dependent on voluntary participation by those knowledgeable and close to the industries being served (Riley *et al.*, 2002; Shelton, 2004; Du Plessis, 2013), namely the livestock farmers and wildlife ranchers, and the specialist predator hunters. Since the support of these stakeholders is vital to the survival of many wildlife populations (Dorrance, 1983), it is important to recognise their role and maintain their authority to manage predation individually (Gier, 1957). The practical field experience, expertise or insights of those directly involved in predation management is as important as sound scientific research for devising effective management strategies (Inskip & Zimmerman, 2009). By integrating local knowledge and culture into research, it may provide the opportunity to gain a better understanding of certain topics (Kolowski & Holekamp; 2006; Dickinson *et al*., 2010) and enhance credibility of data among participants (Chase *et al*., 2000). This approach builds on the initial state of knowledge of the

participants and may aid in developing it further (Bergold & Thomas, 2012). Furthermore, equipping them with suitable technology may also give them a stronger voice with regard to predation management issues (Shelton, 2004; McCall & Dunn, 2012).

Collaborative approaches to research, such as citizen science, participatory research and participatory spatial planning (PSP), are gaining credibility and are promoted because of their efficiency and effectiveness, currency, relevance, responsiveness and low cost (McCall & Dunn 2012). Such approaches are useful for collecting large volumes of data by making use of the efforts of large numbers of people, presenting an opportunity for scientists to collect more data than they would be able to collect on their own (Dickinson *et al*., 2010). Additionally, it promotes engaging the public in scientific research. It often involves research with partners unfamiliar with the practice of academic research. Therefore, the mobile device applications used in this study were designed to build on the participants' everyday experiences, making it easier for them to understand the procedures (Bergold & Thomas, 2012). However, training with regard to finer details of the use of the applications is still necessary. Prospective users may be trained during sessions in which scientists engage with the respective stakeholder groups, or instructions may be built into the applications to guide the user through the process of collecting data (Drill, 2013).

In contrast to "citizen science" projects, which are based on participation by volunteers with a passion for the subject in question (not needing incentive to participate), collection of sensitive information poses several challenges. The advantages of the mobile device applications for collecting data were communicated to stakeholders using various platforms. Despite the interest shown by various stakeholders in utilising the digital data collection tool, interest waned when the proposed methodology was explained to interested individuals, highlighting the need for a more formal approach to put the tool to practical use. Therefore, it may be useful to consider incorporating the use of the mobile device applications into processes run by government departments. For example, making the applications available to extension officers from the Department of Agriculture, Rural Development and Land Reform (DARDLR) when engaging with their respective communities (Section 7.2.2), or making the relevant information extracted from the collected data available to officials from the

Department of Environment, Forestry and Fisheries (DEFF) for issuing of permits to control damage-causing predators (Section 4.3). However, incorporating the applications into government-run processes may cause participants to feel forced to take part, which may cause a decrease in their willingness to participate (Drill, 2013). Rather, programme managers (wildlife managers, scientists and farmers) may determine which types of incentives may be useful to encourage continued participation (Sections 4.3 and 5.2), depending on the particular stakeholder grouping and area from which data is to be collected. Additional incentive schemes may also include using predation risk models to tailor research and predation management strategies according to local conditions (Treves *et al*., 2004). Drawing from examples in the retail and gaming industries, a reward system may be used to keep users interested in continuous use. Rewards may include additional resources such as updates from government departments (DARDLR and DEFF) on predation management-related issues, or illustrating how the data supplied can change policy and regulations to the benefit of the user.

Tulloch *et al.* (2013) advised that the drawbacks associated with participatory approaches should not preclude their use. Rather, future research should draw from the strengths of these datasets, and realise the importance of quality control and quality assurance to limit trade-offs between quality and quantity of data. Volunteer-collected data are useful for fulfilling multiple objectives, which is important where resources for monitoring is limited and programmes therefore need to be cost-effective (Tulloch *et al.,* 2013).

In the process of developing the “Norms and Standards for Managing Damage-Causing Predators” De Waal (2020), much debate has surrounded the management of predators from protected areas. Providing DEFF with scientifically sound data (e.g. the data discussed in Section 7.1.1) to investigate predation “hotspots” in the areas concerned, for example, may aid in the decision-making process of drafting policy in this regard.

7.2.4 Integration with a larger programme of Human-Wildlife conflict management

Scientific information has resulted in predators increasingly being viewed and appreciated as desirable wildlife species by making society aware of the role of predators in ecosystems (Fall, 1990; Messmer *et al.*, 2001). While this has fuelled the controversy surrounding human-wildlife conflicts (Fall, 1990), science has also shifted political attitudes and views from those based on fear and narrow economic interests to those based on a better understanding of ecosystem function and adaptive management (Treves & Karanth, 2003).

Conflict mitigation strategies rely heavily on social sciences, particularly in controversial situations (Koval & Mertig, 2004; Marker & Boast, 2015). It is therefore important for science to inform the development and application of a predation management programme in a complex social and political environment (Shivik, 2004). An important lesson brought back by the study group visiting the USA in 2010 (Section 2.1.3.4) was that there should be a strong focus on the emotions of stakeholders. However, efforts at re-establishing coordinated predation management in South Africa have been unsuccessful to date.

Understanding and altering specific behaviours of the humans (comprising attitudes, beliefs, motivations, behaviours, activity preferences and experiences, which also lead to emotions) and or the predators involved (Shivik, 2004) is important to reduce conflict. The design and implementation of management policies and strategies should build from the cornerstone of biology, making use of available technology (Shivik, 2006) and integrate the social, legal, economic, and political aspects of the conflict (Knowlton *et al.*, 1999; Decker *et al.,* 2002; Macdonald & Sillero-Zubiri, 2002; Riley *et al.*, 2002; Muth *et al.*, 2006; Du Plessis, 2013; Redpath *et al.*, 2013; Terblanche, 2015). Collaboration between tertiary and research institutions, as well as interdepartmental collaboration within these institutions may address existing conflicts as well as new conflicts that may arise from the use of methods such as the one developed in this study (McCall & Dunn, 2012). A focus on the “bigger picture” encourages community participation in finding solutions to conflict (Marker & Boast, 2015). In turn, participation may improve relationships, increase trust, and ultimately reduce conflict (Redpath *et al.*, 2013).

Establishing and paying attention to scientific advisory boards enhances coordination and communication between scientists and the organisations conducting research (Tulloch *et al.,* 2013). However, attempts at establishing scientific advisory boards by the Cape Department of Nature Conservation and Museum Services (Anonymous, 1977/1978) and PMF (De Waal, 2020) have failed in South Africa. Currently, the Red Meat Research and Development (RMRD) provide a regulatory and supervisory service by approving research funding for particular research projects. However, much of the research conducted recently was not in collaboration with the RMRD. In addition, coordination in terms of implementation of management strategies based on current research is still lacking. Careful attention will have to be paid in future in terms of how this could be achieved should a system of coordinated predation management be put in place in the future.

Therefore, an important starting point for re-establishing coordinated predation in South Africa may be to engage the services of government agencies and or NGOs. Examples of such institutions include the Centre for Conservation Peacebuilding (CPeace - see Section 2.1.3.4) and the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL). CPeace specialises in engaging stakeholders in working towards solutions to human-wildlife conflict on national level. Workshops presented by CPeace provide a platform for stakeholders to set priorities and devise specific project plans collaboratively. SASSCAL provides a framework built on institutional cooperation and partnerships to ensure capacity building and the provision of services based on multidisciplinary research (Olwoch, 2018). Furthermore, South Africa may benefit from drawing from the knowledge and experience obtained through Farming Systems Research and Extension programmes (Francis & Hildebrand, 1989) implemented elsewhere.

8 Conclusions

"It is evident that many great and useful objects can be attained in this world only by cooperation."

– Thomas B. Macaulay –

Past systems of predation management in South Africa formed part of official government structures. These old South African systems and official systems of predation management currently operational in the USA and Australia proved the value of coordinated action. Since the disbandment of government-subsidised predation management systems and despite dedicated efforts over the past four decades by various stakeholder groups, the lack of official structures has hampered progress with regard to human-predator conflict mitigation in South Africa.

The driving force in developing a Management Information System (MIS) was the lack of coordination, institutional memory and scientific information in South Africa. The databases described in the study form part of an MIS to serve industry with an information management function on which to base coordinated action.

The following aspects were identified during the development of the MIS as impeding progress towards a coordinated system of predation management:

- A lack of coordinated, structured and focused approach to research;
- Collecting data from users on a voluntary basis using questionnaires poses problems;
- A lack of communication among the various stakeholder groupings;
- Limited utility of an MIS for disseminating information tailored to stakeholder groupings where there is a lack of communication regarding specific information needs from industry;
- Individual stakeholders and stakeholder groupings refusing to cooperate with other individuals or groupings;
- Distrust among stakeholders as individuals and or groupings pursue disparate objectives;

- Frequent shifts in government structures, coupled with difficulties in identifying and communicating with officials knowledgeable in predation management-related matters within the respective departments;
- A lack of coordination within as well as between government departments regarding predation management-related matters.

Research forms an integral part of coordinated predation management. However, such research continues to be conducted in a fragmented and uncoordinated manner in South Africa. Therefore, a user-friendly tool in the form of mobile device applications was designed for collecting predation management data to incorporate into the MIS. The evolution or succession of methods used in this thesis to collect detailed longitudinal data gave rise to the development of this tool for collecting standardised, real-time predation management data on a large scale. For such a tool to be useful in terms of providing meaningful insight into predation management, however, a reliable framework is required according to which future research may be conducted.

The existence of an MIS containing institutional memory is in itself not enough to aid coordinated action. Cooperation from stakeholders to supply or obtain information and feedback in the MIS is crucial to ensure the flow of information throughout the system. A recent development in terms of coordinated predation management in South Africa is the identification of stakeholders and role players. However, some ambiguity still exists regarding the role and specific responsibilities of some stakeholder groups, while involvement from some stakeholders (particularly some government departments) remains a serious challenge (De Waal, 2020).

Stakeholders and role players must understand their respective roles and how it fits into the broader system. Individuals or groups should also be aware of the role and degree of involvement of other individuals or groups to avoid duplication in terms of planning and implementation and thereby wasting time and valuable resources. Understanding the role and responsibilities of other individuals or groups involved should also eliminate perceptions of some threatening the existence or taking over the role of others (De Waal, 2020). It is therefore important that future actions be coordinated, under an authoritative body, with a strong focus on social aspects to

establish an official framework to mitigate human-predator conflict in South Africa. Under such a body, predation management may be professionalised by developing sound policies, improved methodology, protocols, best practices and ensuring accountability with the aid of an MIS (Benymanz, 1989).

This study illustrated the varied nature of predation management practiced on livestock farms (Section 7.1.1) and stressed the importance of bigger data sets covering larger areas and longer periods. Within a coordinated predation management programme and with the cooperation of government departments, the mobile device applications developed in this study may assist government departments to obtain information pertaining to the prevailing situation regarding human-predator conflict on local, regional, provincial as well as national level, and communicate research outputs to livestock producers, wildlife ranchers and specialist predator hunters.

8.1 Recommendations

The mobile device applications developed in this study provide the opportunity to collect predation management data in a more time and cost-effective manner compared to conventional methods. The applications enable the collection of large volumes of data that require minimal processing (Will *et al*., 2014) and incorporate local knowledge for multidisciplinary studies (Shelton, 2004; Thorn *et al*., 2013). The mobile device applications developed in this study should be refined and tested on a larger scale and in different settings, to identify potential shortfalls and ensure relevance in various scenarios. The technology available allows continuous refining and improvement of human-predator conflict mitigation approaches. Therefore, future research will focus on testing the methodology among farmers, wildlife managers (government officials) and the scientific community.

When incorporated in a national database as part of the MIS, the data collected with a methodology such as that developed and offered by this study present the opportunity to assist authorities and industry with the following aspects:

8.1.1 Identifying and or predicting predation hotspots to assess predation impacts and allocate resources accordingly. Here, a multidisciplinary approach is

important to identify biological and social drivers behind specific conflict situations in order to assign experts to mitigate the conflicts.

8.1.2 Evaluating the efficiency of management strategies under different circumstances, as well as before and after implementation of a coordinated programme.

8.1.3 Monitoring outcomes of management strategies to shed light on emerging conflicts (Bergold & Thomas, 2012) and ensure continuous improvement of existing approaches. Here, investing in long-term research is vital to the continued success of a programme.

8.1.4 Formulating Best Management Practices, incorporating the development of devices and strategies which promote humane and selective predator control (Andelt *et al.*, 1999). Local knowledge is as important as scientific information in this process.

8.1.5 Developing policy. Policy development requires research to be focused and structured. In turn, policy should promote the collection of data to ensure the continuous flow of relevant, current information into the MIS to provide a basis for evaluation and monitoring of a coordinated programme. Furthermore, government funding may promote more targeted research.

8.1.6 Providing extension services. Despite various predation management manuals and guidelines being freely available (Davies-Mostert *et al.*, 2007; Smuts, 2008; The Predation Management Forum, 2016), predation still appears to be a significant challenge facing farmers and ranchers. Moreover, information regarding predation management is available on various platforms. However, some sources provide contrasting information, fuelling controversy and emotions among different stakeholder groups. An MIS should serve as a platform to combine the efforts of tertiary and research institutions, government, as well as non-governmental organisations to communicate data gaps and research outcomes to relevant stakeholders. Ensuring the distribution of current, relevant information from trusted sources via an authoritative body is essential to reduce public misconceptions regarding predation management (Andelt *et al.*, 1999).

8.1.7 Providing predation management training.

- Preventive predation management training to agricultural extension officers (DARDLR), livestock farmers and wildlife ranchers.

- Predator control training to livestock farmers and wildlife ranchers who conduct predator control on their properties, as well as specialist predator hunters and conservation officials (DEFF) who provide technical assistance to landowners.
- A training platform is crucial to ensure that relevant research recommendations are incorporated into the system and implemented.

One of the major shortcomings in working toward a system of coordinated predation management in South Africa remains the lack of focus on the human dimensions of human-predator conflict. After the new geopolitical dispensation in 1994, the NPAPC published the National Policy and Strategy for Problem Animal Control in South Africa but it was not implemented. Without the necessary focus on social aspects of the human-predator conflicts in South Africa, such as the factors listed in the previous section, future efforts to implement such strategies may also be futile.

It is recommended that all attempts at mitigating human-predator conflicts incorporate a specific social component. Tertiary institutions should be represented by natural scientists as well as sociologists. In turn, a sharper focus on the human dimensions in these conflicts may promote collaboration within as well as between tertiary and research institutions, government and non-government organisations, farmers, ranchers, predation management specialists and the public. Such collaboration is necessary on local, regional, provincial, as well as national level to advance in a meaningful way toward a system of coordinated predation management. Therefore, it is recommended that future moves towards coordinated predation management make use of services such as those provided by CPeace or SASSCAL.

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Appendix 1

Gunter (2008) studied several sets of data, namely data recorded in the historical hunt reports, additional data supplied in the reports, information contained in the quarterly inspection reports, as well as the data used in other studies (Robel, 1981; Brand, 1989; Lawson, 1989; Graham *et al.*, 2005; Swanepoel, 2008, Du Plessis, 2013; Thorn *et al*., 2013). This highlighted serious shortcomings in predation and predation management research. Clearly, some measure of standardisation of the type and format of data was necessary to conduct predation management studies on a larger scale. Therefore, modified data capture forms (questionnaires) to collect such data was proposed by Gunter (2008).

Questionnaires

The forms proposed by Gunter (2008) to capture data were designed to include more detail on livestock losses such as:

(a) the date and location of each predation incident and predator control activity on a farm;
(b) the species (goat, sheep, cattle), sex and age of animals killed by predators;
(c) the species, age, sex and stomach content of each animal killed or caught in control operations;
(d) the method used in each control operation; and
(e) whether the animal killed or caught was the target animal (animal suspected of predation).

The purpose of the new design was to enable investigation into the cause-and-effect of predation and predation management on farm-level, as well as on a larger scale. The evolution of the design of these standardised forms are reviewed and briefly discussed here.

In studies such as that by Brand (1989) and Lawson (1989), information regarding different land uses, buildings, other livestock, game kept on the farm, fencing, husbandry practices, hunting clubs and hunting methods was recorded during control operations. In the present study, the questionnaires were designed to record predation management practices such as preventive methods, including fencing and husbandry

practices; different types of livestock and or wildlife species kept on each farm; and lethal predator control methods.

Questionnaires were used to collect information during 2011, 2012 and 2014 and are named accordingly. Each questionnaire consisted of two parts, hereafter referred to as Part 1 and Part 2.

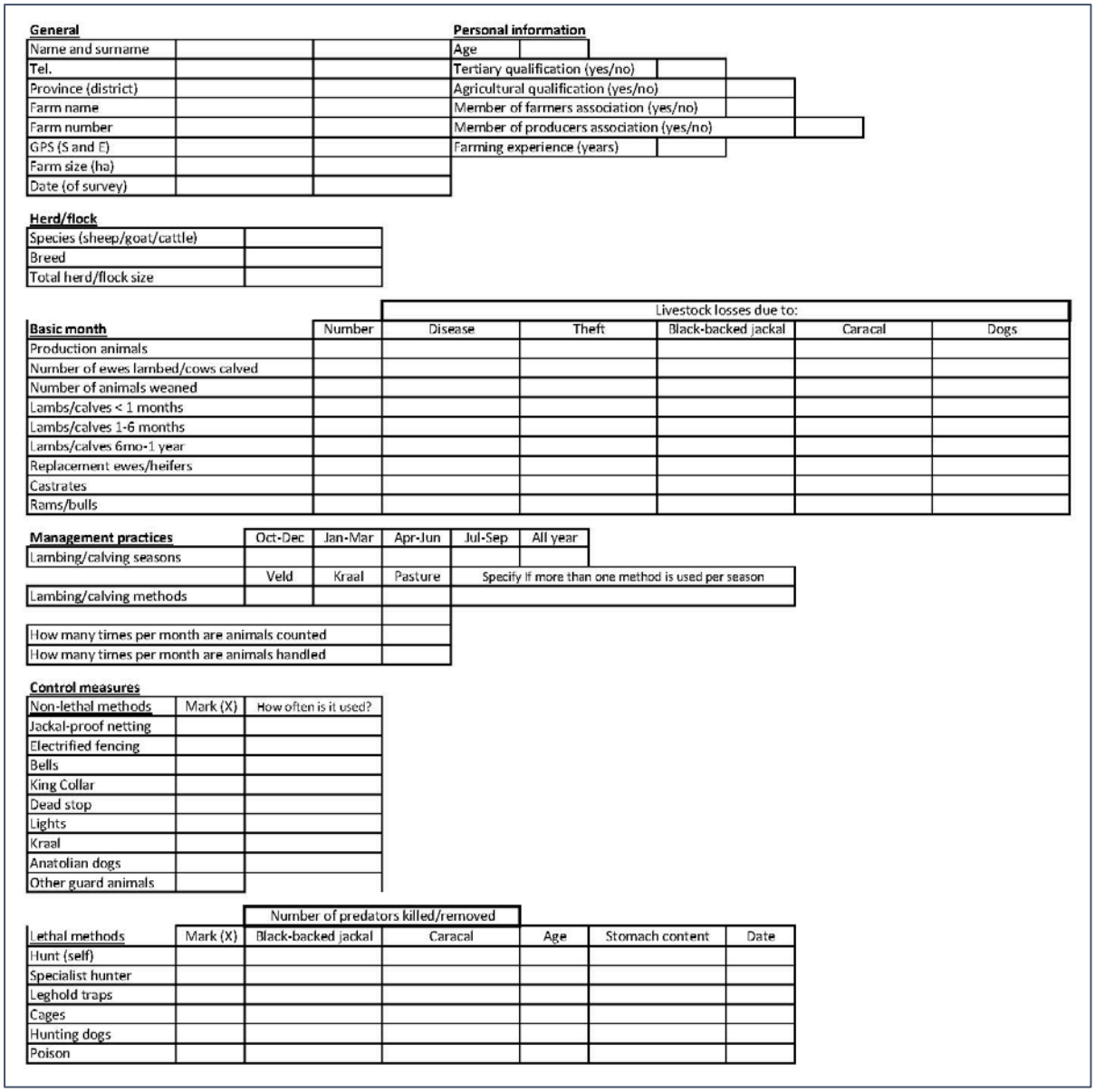
The 2011-Questionnaire

The questionnaire contained questions similar to those suggested by Gunter (2008), as well as additional questions regarding farm management and preventive predation management practices employed by farmers. The format resembled the questionnaires used by Van Niekerk (2010).

Part 1 was designed to collect the following basic information:

- personal details of each farmer to enable demographic analyses;
- physical characteristics of the farm (size and location);
- farm management practices (including husbandry practices);
- breed, herd/flock size and composition;
- livestock losses experienced during the past month;
- predation management methods used (non-lethal methods and the frequency with which they are employed to prevent predation, as well as lethal methods); and
- the species, number, sex, age and stomach content of predators killed or removed in control operations during the past month.

Since the study was to focus mainly on predation by black-backed jackal and caracal, provision was made in the questionnaire to record losses caused by these species and the number and details of these two species removed during predator control operations. It is also known that vagrant dogs are responsible for large numbers of livestock losses in some areas. To gauge the proportion of damage by vagrant dogs compared to black-backed jackal and caracal damage in these areas, provision was also made for recording the damage caused by vagrant dogs.



General

Name and surname		
Tel.		
Province (district)		
Farm name		
Farm number		
GPS (S and E)		
Farm size (ha)		
Date (of survey)		

Personal information

Age	
Tertiary qualification (yes/no)	
Agricultural qualification (yes/no)	
Member of farmers association (yes/no)	
Member of producers association (yes/no)	
Farming experience (years)	

Herd/flock

Species (sheep/goat/cattle)	
Breed	
Total herd/flock size	

		Livestock losses due to:				
Basic month	Number	Disease	Theft	Black-backed jackal	Caracal	Dogs
Production animals						
Number of ewes lambed/cows calved						
Number of animals weaned						
Lambs/calves < 1 months						
Lambs/calves 1-6 months						
Lambs/calves 6mo-1 year						
Replacement ewes/heifers						
Castrates						
Rams/bulls						

Management practices	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	All year
Lambing/calving seasons					

	Veld	Kraal	Pasture	Specify if more than one method is used per season
Lambing/calving methods				

How many times per month are animals counted	
How many times per month are animals handled	

Control measures

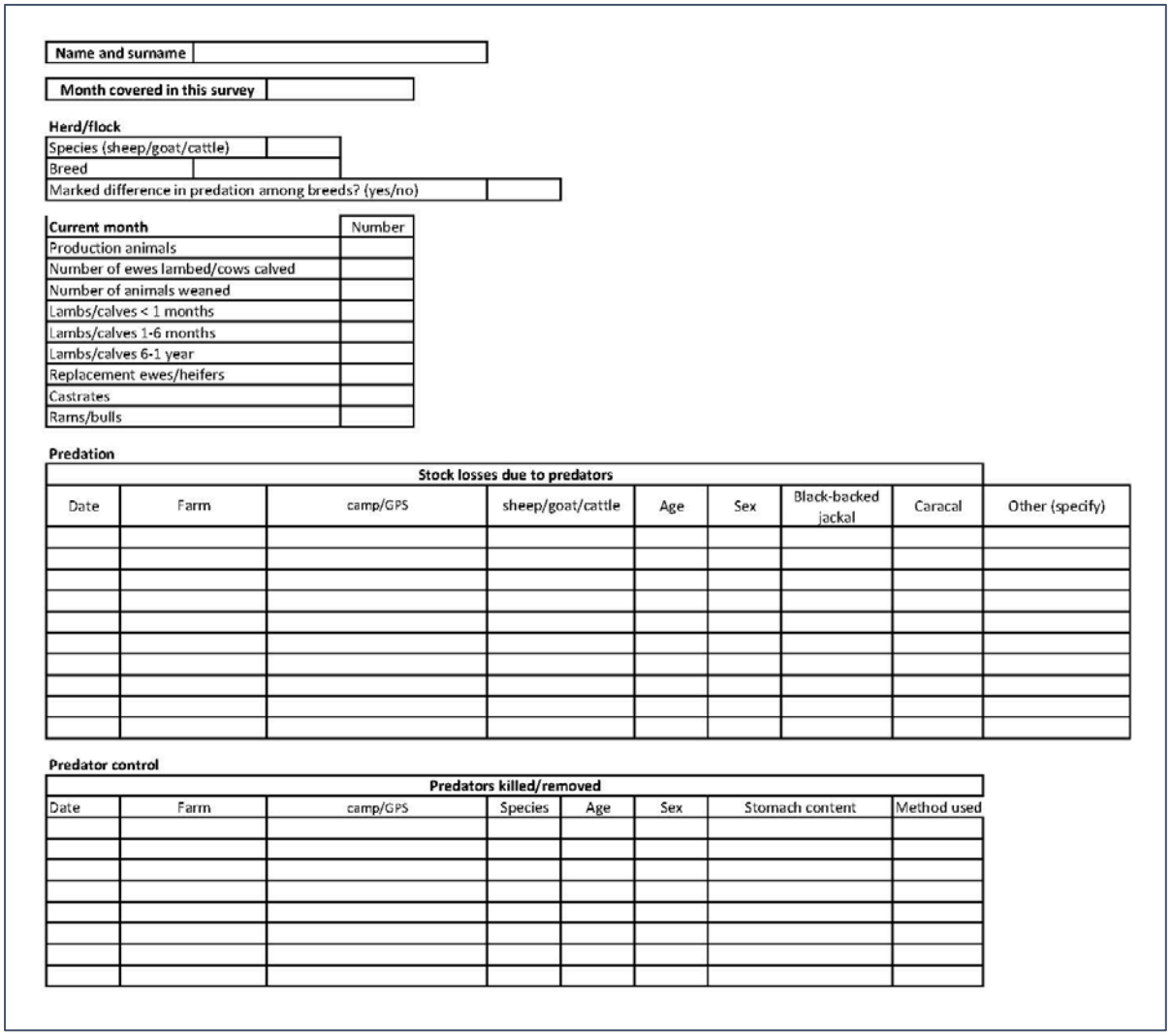
Non-lethal methods	Mark (X)	How often is it used?
Jackal-proof netting		
Electrified fencing		
Bells		
King Collar		
Dead stop		
Lights		
Kraal		
Anatolian dogs		
Other guard animals		

		Number of predators killed/removed				
Lethal methods	Mark (X)	Black-backed jackal	Caracal	Age	Stomach content	Date
Hunt (self)						
Specialist hunter						
Leghold traps						
Cages						
Hunting dogs						
Poison						

Figure 1a Part 1 of the 2011-Questionnaire, containing fields for recording information regarding physical and management characteristics of the farm, including the predation experienced and predation management conducted during the month prior to the visit.

Part 1 made provision for recording the details of only one farm and one herd or flock at a time. Farmers who owned more than one farm and or kept multiple livestock species and or breeds on a farm, were therefore required to complete an additional copy of the questionnaire for each of the farms as well as each of the flocks on a farm. This made the process tedious and time-consuming. In addition, Part 1 was designed to record total livestock losses during the month prior to the start date of the study. Therefore, it lacked the utility of recording each predation incident for the first month of the study.

Part 2 was designed to collect detailed information regarding livestock losses as well as predator control conducted on each farm on a monthly basis.



Name and surname	

Month covered in this survey	

Herd/flock

Species (sheep/goat/cattle)	
Breed	
Marked difference in predation among breeds? (yes/no)	

Current month	Number
Production animals	
Number of ewes lambed/cows calved	
Number of animals weaned	
Lambs/calves < 1 months	
Lambs/calves 1-6 months	
Lambs/calves 6-1 year	
Replacement ewes/heifers	
Castrates	
Rams/bulls	

Predation

Stock losses due to predators								
Date	Farm	camp/GPS	sheep/goat/cattle	Age	Sex	Black-backed jackal	Caracal	Other (specify)

Predator control

Predators killed/removed							
Date	Farm	camp/GPS	Species	Age	Sex	Stomach content	Method used

Figure 1b Part 2 of the 2011-Questionnaire, designed for recording detailed information on livestock losses and subsequent predator control on a monthly basis.

Despite providing step-by-step instructions and explanations on completing each of the fields on the questionnaires, some farmers did not complete questionnaires in a uniform manner. In an attempt to address the apparent confusion among farmers regarding completing the questionnaires, the questionnaires were modified for use in 2012.

The 2012-Questionnaire

Part 1 (Fig. 1c) was modified for recording only the personal details of the farmer and details regarding each farm and the animals kept on the farm. All livestock losses and predator control were to be recorded in Part 2 (Fig. 1c). Further modification to Part 1 included provision to record the details of up to three farms per page, which facilitated recording each farm's physical characteristics and management practices separately (Fig. 1c).

Personal information

			Yes/No	Specify (optional)
Name and surname				
Date of birth		Tertiary qualification		
Tel.		Agricultural qualification		
Date of survey		Member of farmers association		
Farming experience (years)		Member of producers association		

General	Farm 1		Farm 2		Farm 3	
Farm name						
Farm number						
GPS coordinates	S:	E:	S:	E:	S:	E:
Farm size (ha)						
Province and district						

If the farms are managed as a unit, please indicate during which times of the year they are moved, and to which farms

Management practices

Herd/flock	Farm 1	Farm 2	Farm 3
Species (sheep/goat/cattle)			
Breed			
Total herd/flock size			
How many times per month are animals counted			
How many times per month are animals handled			

Lambing/calving seasons	Farm 1	Farm 2	Farm 3
Oct-Dec			
Jan-Mar			
Apr-Jun			
Jul-Sep			
All year			
Lambing/calving methods	Farm 1	Farm 2	Farm 3
Veld			
Kraal			
Pasture			
Shepherds			

Control measures	Farm 1		Farm 2		Farm 3	
Non-lethal methods	Mark (X)	How often is it used?	Mark (X)	How often is it used?	Mark (X)	How often is it used?
Jackal-proof netting						
Electrified fencing						
Bells						
King Collar						
Dead stop						
Lights						
Olfactory deterrents (smells)						
Kraal						
Anatolian shepherd dogs						
Other guard animals						

Lethal methods Mark (X)	Hunt (self)	Specialist hunter	Leghold traps	Cage traps	Hunting dogs	Poison

Figure 1c Part 1 of the 2012-Questionnaire - only demographic information, physical characteristics of each farm, husbandry practices and preventive predation management methods on each farm is recorded.

The modifications to the 2012-Questionnaire required farmers to complete both Part 1 and Part 2 on the day of the visit, thereafter only submitting Part 2 each month for the next 11 months. Familiarising farmers with Part 2 in this manner eliminated some of the confusion experienced with the 2011-Questionnaire.

The 2012-Questionnaire thus provided a higher degree of standardisation of the data. In addition, provision was made for recording livestock predation by predator species other than black-backed jackal, caracal and vagrant dogs to allow comparison of the extent and distribution of predation by other predator species.

Name and surname	

Report month	

Herd/flock

Species (sheep/goat/cattle)	
Breed	
Total herd/flock size	

Comments

	Total		
Current month	Sheep	Goats	Cattle
Production animals			
Number of ewes lambed/cows calved			
Number of animals weaned			
Lambs/calves < 1 months			
Lambs/calves 1-6 months			
Lambs/calves 6mo-1 year			
Replacement ewes/heifers			
Castrates			
Rams/bulls			

Predation

Livestock losses due to predators								Losses due to other causes
Date	Farm	camp/GPS	sheep/goat/cattle	Number	Age	Sex	Predator responsible	Specify (eg. disease/drought)

Predator control

Predators killed/removed								
Date	Farm	camp/GPS	Species	Number	Age	Sex	Stomach content	Method used

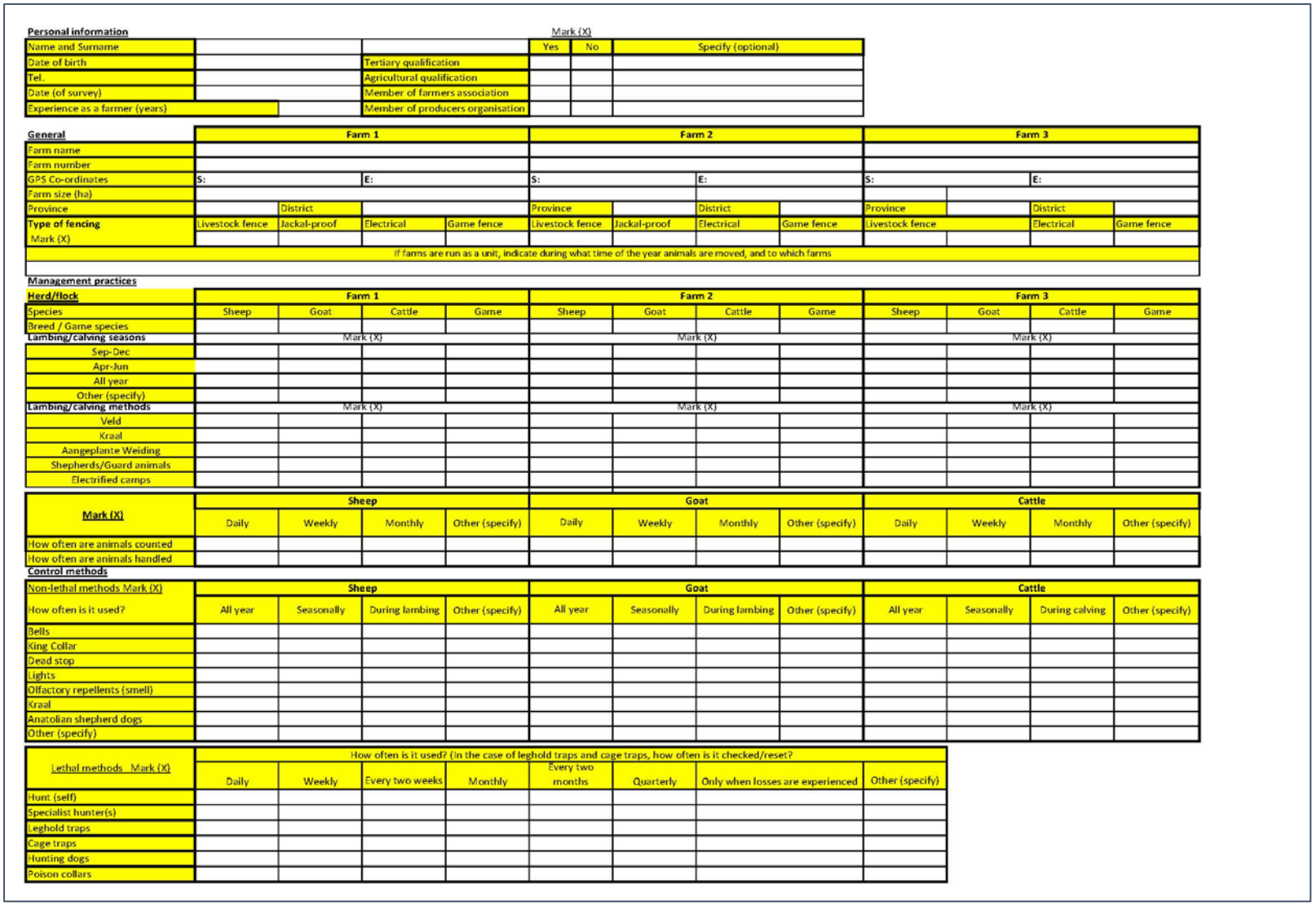
Figure 1d Part 2 of the 2012-Questionnaire - which includes a “Comments” box for recording additional qualitative data.

Part 2 was modified to provide for recording the total herd or flock size every month to allow calculation of stock losses as a percentage of the total herd or flock size. However, according to one of the producers, providing for a single count of all animals is more practical, since many farmers do not count their livestock as regularly, and since some animals (particularly lambs) are not considered part of the flock, because they will most likely be sold.

The 2014-Questionnaire

In 2014 the questionnaires were modified again to include predation on herbivorous wildlife species (game) that may be present on some livestock farms, and to allow for recording more than one herd/or flock of animals per farm. (Figs. 1e and 1f). To allow for comparison of predation losses with losses due to other causes, such as theft and disease, provision was made to record such losses as well.

Because these questionnaires were designed as Microsoft Excel spreadsheets for electronic completion, the fields to be completed (or questions to be answered) were indicated in yellow. Drop-down menus were also incorporated into Part 2 of the questionnaire to ensure a higher degree of standardisation of the data. Predefined lists were compiled for recording the predator species responsible for damage, other causes of livestock losses, the sex and age classes of livestock lost, the species, sex and age classes of predators removed during control operations, as well as the stomach contents of the predator and the control method used to remove the predator.



Personal information

			Mark (X)		
			Yes	No	Specify (optional)
Name and Surname		Tertiary qualification			
Date of birth		Agricultural qualification			
Tel.		Member of farmers association			
Date (of survey)		Member of producers organisation			
Experience as a farmer (years)					

General

	Farm 1				Farm 2				Farm 3			
Farm name												
Farm number												
GPS Co-ordinates	S:		E:		S:		E:		S:		E:	
Farm size (ha)												
Province		District			Province		District		Province		District	
Type of fencing	Livestock fence	Jackal-proof	Electrical	Game fence	Livestock fence	Jackal-proof	Electrical	Game fence	Livestock fence		Electrical	Game fence
Mark (X)												

If farms are run as a unit, indicate during what time of the year animals are moved, and to which farms

Management practices

Herd/flock

	Farm 1				Farm 2				Farm 3			
Species	Sheep	Goat	Cattle	Game	Sheep	Goat	Cattle	Game	Sheep	Goat	Cattle	Game
Breed / Game species												
Lambing/calving seasons	Mark (X)				Mark (X)				Mark (X)			
Sep-Dec												
Apr-Jun												
All year												
Other (specify)												
Lambing/calving methods	Mark (X)				Mark (X)				Mark (X)			
Veld												
Kraal												
Aangeplante Weiding												
Shepherds/Guard animals												
Electrified camps												

Mark (X)	Sheep				Goat				Cattle			
	Daily	Weekly	Monthly	Other (specify)	Daily	Weekly	Monthly	Other (specify)	Daily	Weekly	Monthly	Other (specify)
How often are animals counted												
How often are animals handled												

Control methods

Non-lethal methods Mark (X)	Sheep				Goat				Cattle			
How often is it used?	All year	Seasonally	During lambing	Other (specify)	All year	Seasonally	During lambing	Other (specify)	All year	Seasonally	During calving	Other (specify)
Bells												
King Collar												
Dead stop												
Lights												
Olfactory repellents (smell)												
Kraal												
Anatolian shepherd dogs												
Other (specify)												

Lethal methods Mark (X)	How often is it used? (In the case of leghold traps and cage traps, how often is it checked/reset?							
	Daily	Weekly	Every two weeks	Monthly	Every two months	Quarterly	Only when losses are experienced	Other (specify)
Hunt (self)								
Specialist hunter(s)								
Leghold traps								
Cage traps								
Hunting dogs								
Poison collars								

Figure 1e Part 1 of the 2014-Questionnaire. To ensure standardisation of data, lists of predefined options were provided for the participant to choose from.

Name and surname		

Report month	

Herd/flock

Is there a marked difference in predation among different breeds? Mark (X)	Yes	No

Current month	Sheep	Goat	Cattle	Game
Total herd/flock size				
Breeding ewes/heifers				
Number of ewes lambed/cows calve				
Lambs/calves < 1 month				
Lambs/calves 1-6 months				
Lambs/calves 6 months-1 year				
Ewes/heifers 1-2 years				
Castrates				
Rams/bulls				

Remarks

Date	Farm	Livestock losses due to predation							Other causes
		GPS Coordinates		Breed/Game species	Number	Age	Sex (M/F)	Predator responsible for damage	Specify (e.g. Theft, Disease, drought, etc.)
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						

Predators removed/killed								
Date	Farm	GPS Coordinates		Species	Number	Age	Sex (M/F)	Stomach content	Method used
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						
		S:	O:						

Figure 1f Part 2 of the 2014-Questionnaire. The questionnaire contains drop-down menus for standardisation of data.

Software

Since some sort of incentive would be necessary to motivate farmers to continually submit data, and since connecting specific incidents of predation and control activities with specific locations remained a challenge throughout the study, alternatives were sought to address these issues. During the time in which the software was being modified, other methods of data collection were also explored.

- mobile text messaging (sms) and e-mail messages, in which monthly predation and or predator control could be reported in near-real time as comma-separated values (CSV);
- Microsoft Access and Microsoft Excel databases, which would not require converting any of the data for analysis;
- EvaSys Survey Automation Suite v4.0, to enable online data collection via the UFS website; and ultimately
- mobile device applications.

It is important to note the advantages and disadvantages of these electronic methods considered for data collection (Section 3.3.2):

- Although SMS and e-mail messaging provided the opportunity for recording of the data on a near real-time basis, standardisation of data was not possible. In addition, if the data supplied by participants do not correspond to the specific sequence (order) in which questions or fields are listed in the questionnaire provided to participants, data handling increases markedly.
- The greatest advantage of the Microsoft Access and Microsoft Excel databases is that the data received from participants can be incorporated directly into the existing database without much data handling, thereby eliminating transcription error. Quantitative data is standardised, owing to the drop-down menus containing predetermined values which participants can choose from. Questionnaires in these formats also facilitate the collection of large amounts of detailed data. A further advantage of the Microsoft Access option, is that forms can be created to guide the participant through the process of completing the questionnaire.
- While the EvaSys software present a useful tool for administering online questionnaires, it is more suitable for collecting qualitative data. Although the

collection of some quantitative data could also be incorporated into EvaSys questionnaires, it was not a suitable option for the amount and type of data to be collected.

- With all of these methods, low overall and item response was still likely to be a major challenge.

These methods were explored in efforts to provide the parties directly affected by predation or involved in predation management with a non-intrusive method of reporting more accurate, real-time data pertaining to human-predator conflict in a way that is less time-consuming. However, as none of these methods met said requirements, and as the use of mobile device applications became commonplace, attention was turned to mobile applications as aid in data collection.