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# Human dimensions of coexistence with lions: attitudes, wellbeing and economic valuation

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# Abstract

Interactions between people and large carnivores often entail serious consequences for both: killing by people is among the top threats to large carnivore populations, and attacks on livestock and people by predators threaten lives and livelihoods. In order to understand and alleviate human-wildlife conflict, it is important to understand these interactions from the perspectives of the people involved. There have been repeated calls for improved understanding of the non-material aspects of human-wildlife conflict, but these are still poorly understood. Using ordinal logistic regression models, I investigate the importance of a range of tangible and intangible factors on attitudes to coexisting with lions (*Panthera leo*) among subsistence farmers, including the costs and benefits of wildlife presence, emotion, culture, religion, vulnerability, risk perception, notions of responsibility and personal value orientations. I found intangible factors to be as important as tangible factors in understanding attitudes to coexisting with lions in agro-pastoral communities on the border of Hwange National Park in Zimbabwe. Fear emerges as the variable with the highest effect size in the attitude models. The degree to which benefits accrue to households from the nearby protected area was also highly influential, as was the numbers of livestock lost, perceived risk of lion encounters, age, number of dependants, ecocentric value-orientation, and participation in conflict mitigation programmes. Depredation of livestock is often assumed to be the crux of human-carnivore conflict, but metrics of livestock loss did not dominate attitudes to coexistence with lions. I raise questions about the widespread reliance on socio-economic variables in the field of human-wildlife conflict and coexistence, as some such variables appeared to be spuriously associated with attitude when used in isolation. Economic valuation allows for the quantification of the total value of carnivore presence from the perspective of the local communities, including the impact of intangible factors. I found that the total value of an additional lion was negative US$180 per person per year, which is several hundred times larger than the market value of the average per capita loss of livestock. Under the assumptions of simplifying economic theory, this discrepancy reveals that the value of the

material losses, which has been the only quantitative data available for compensation schemes and conservation actions so far, substantially underestimates the total costs experienced by the communities that live in the closest proximity to predator populations. However, there are substantial uncertainties around the cognitive process used to relate costs to probability of loss, and around risk perception. The impact of carnivore presence can also be quantified through wellbeing analyses. By calculating the marginal rate of substitution between the effect of wealth wellbeing and the effect of experiencing livestock loss on wellbeing, I estimate economic value of this impact to be US$5800 annually per person. Fear of lions had an equivalent effect on the wellbeing of the people living alongside lions to experiencing livestock loss. Compensating economically for the full costs experienced in association with the presence of lions would entail substantial cost. Furthermore, conservation practitioners or wildlife managers would have to rethink who they provide compensation for – traditional compensation schemes compensate livestock owners, but the intangible harms of carnivore presence are not limited to people who own livestock. This greatly increases the scope and cost of compensation schemes and initiatives that aim to incentivise tolerance towards wildlife by generating financial benefits. However, it is difficult to envision successful mitigation of human-wildlife conflict without operating with a clear picture of the total costs experienced and perceived by the people who live alongside wildlife.

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# CHAPTER 1. THESIS INTRODUCTION

## 1.1. The urgency of carnivore conservation

The neighbourly relations between lions and the communities that live alongside them are often strained. Understanding the attitudes of the stakeholders that live closest to what can be either the frontline of conflict or the frontier of coexistence is important - both for the pragmatic purposes of effectively tailoring conservation policies but also from the perspective of doing justice to the people who bear the brunt of the costs of maintaining the global good of lion presence.

There is a an urgency to the conservation of large carnivores because they fulfil important ecological functions (Ripple et al., 2014), serve as potent umbrella and ambassadors species (Ripple et al., 2017, Macdonald et al., 2017b, Macdonald et al., 2015) and hold economic (Macdonald et al., 2017a) and intrinsic value (Vucetich et al., 2015, López-Bao et al., 2017). Most large carnivores have suffered large population declines and range contractions (Ripple et al., 2014) and lions in particular have experienced a 92% reduction in their range (Bauer et al., 2016). Human-lion conflict is among the top threats (IUCN, 2006a, IUCN, 2006b, Funston et al., 2016). Marchini and Macdonald (2012) argue that across the wide range of human-wildlife conflicts, humans are the only constants and resolution depends on the thoughts and actions of the people involved.

## 1.2. The determinants of tolerance of large carnivores

The experience of damage caused by carnivores often plays a role in determining the degree of tolerance of carnivores (Dickman et al., 2013, Gebresenbet et al., 2018b, Hariohay et al., 2018, Mitchell et al., 2019, McKay et al., 2018, Messmer, 2009, Tessema et al., 2010), but it has been recognised that direct damage is not the only driver of hostility towards damage-causing wildlife, and not necessarily even the main driver. There is evidence that reducing such damage may not

reduce hostility (Dickman, 2010), e.g. from areas with cheetah depredations in Namibia where 40% of farmers that no longer experienced depredation still removed cheetahs (*Acinonyx jubatus*) from their land (Marker, 2002). In many contexts, personal experience of depredation does not significantly increase hostility to carnivores (Dickman et al., 2013), with examples from Brazil (Marchini, 2010, Porfirio et al., 2016), South Africa (Lagendijk and Gusset, 2008), Kenya (Broekhuis et al., 2018) and India (Suryawanshi et al., 2014). A meta-analysis of attitudes to damage-causing mammals by Kansky et al. (2014) found that carnivores elicited tolerance levels lower than expected based on probability of experiencing damage. Pooley et al. (2017) in their review of human-predator relationships recognised the same phenomenon and concluded that there is too much focus on negative impacts, oversimplified assumptions that antagonistic behaviours towards wildlife occur in proportion to levels of harm experienced , and technical fixes that fail due to a failure to engage local stakeholders, address hidden costs or understand cultural conceptions of cause of conflict. The authors further argue that to successfully mitigate negative interactions between people and wildlife, an interdisciplinary approach is required to determine what the conflicts are really about and explore the cultural foundations of how animals are viewed (Pooley et al., 2017). In order to successfully achieve such interdisciplinary research, social science expertise and rigorous study design is necessary (St John et al., 2014).

Rational choice theory often poorly explains human-carnivore interactions (St John et al., 2010, Gebresenbet et al., 2018a). To mitigate conflict, we need to understand the attitudes of the people involved and the complex web of socio-economic factors, past experiences, culture, beliefs, costs and benefits that influence those attitudes (Browne-Nuñez and Jonker, 2008, Dickman, 2010, Dickman et al., 2013, Inskip et al., 2014). Hill (2004) argues that mitigation of human-wildlife conflict should begin with understanding farmer's perspectives.

This work aims to investigate the factors that underlie the attitudes to coexistence with lions, the tangible and intangible costs and benefits associated with lion presence and how these impact the

wellbeing of the people who live alongside lions on the border of Hwange National Park in Zimbabwe.

## 1.3. Structure of this thesis

This thesis is structured around three central topics: First, quantitative analysis of attitudes. Second, economic valuation through choice experiments. Third, quantifying the impact of lion presence on wellbeing. Each topic consists of one research paper formatted for journal submission and presented independently. Accordingly, this introduction chapter to the thesis is divided according to these three topics. The three data chapters are preceded by a chapter outlining the exploratory interviews that were carried out prior to data collection, and followed by a chapter presenting a general conclusion and synthesis of my findings.

## 1.4. Part 1: Attitudes to coexistence with large carnivores

### 1.4.1. Conservation psychology – theoretical frameworks for understanding conservation behaviour

#### 1.4.1.1. What is conservation psychology?

The field of conservation psychology has emerged over the last decade and is the study of the reciprocal relationship between humans and nature (Saunders, 2003). It uses psychological theories and methods to understand and solve issues related to human aspects of conservation (Saunders, 2003). Topics that fall within this field include studies of conservation-relevant behaviours such as recycling (McKenzie‐Mohr and Oskamp, 1995, Oskamp, 2002, Granzin and Olsen, 1991), human-animal interactions (Fernandez-Llamazares et al., 2020, Perry et al., 2020), environment and identity (Clayton and Opotow, 2003) environmental education and socialization (Thomas et al., 2019),

environmental attitudes (Nilsson et al., 2020, Floress et al., 2017), and environmental conflict (González-Hidalgo and Zografos, 2020).

The field is rooted in behavioural psychology and environmental psychology, and there is some confusion about the delineation of conservation psychology relative to environmental psychology. Clayton and Brook (2005, p.89) differentiates the two fields as follows "Environmental psychology seeks to understand how people are influenced by their natural and human-built physical environments, and conservation psychology draws extensively from environmental psychology research... However, conservation psychology also examines nonphysical factors that promote or inhibit environmental conservation, and thus incorporates research from the social, developmental, clinical, or cognitive areas". Conservation psychology also has an explicit value-based orientation: the aim of the discipline is to promote sustainable behaviours with regards to components of nature (Clayton and Brook, 2005).

1.4.1.2. Models and frameworks of conservation psychology

Several disciplines have developed models of people's decision-making process, and economic models of natural resource use based on expected utility theory have been widely applied for decades (St John et al., 2010). Social-psychology has added further dimensions to more accurately understand human behaviour beyond the theoretical purely rational decisionmaker, by including socio-psychological characteristics of the individual and the influence of the society that the individual lives within (St John et al., 2010). Individuals' behaviour is mediated by institutions, such as formal and informal laws, which shape attitudes, social norms and behaviour (St John et al., 2013, Agrawal, 2001). Behavioural change is influenced by the direction and strength of attitudes, individual capabilities, social norms, incentives, and structures such as formal and informal institutions, and the wider socioeconomic and political context (Saunders et al., 2006). Several theoretical frameworks have been developed within conservation psychology, or adopted from the

wider field of behavioural psychology, to understand human behaviour. The frameworks broadly fall within four approaches: rational-economic models, social-dilemma models, attitude models, and models based on behaviour modification and learning theory (Kurz, 2002).

*Behaviourism*: In this approach, the object of psychology is the observable phenomenon of behaviour (Skinner, 1965), and behaviours are explained by contextual factors. This is demonstrated by the triple-contingency relationship model which sees behaviour as contingent on discriminative stimuli, and the consequences of the behaviour determines whether it will be repeated or disappear (Clayton and Brook, 2005). An example of a discriminative stimulus would be the presence of cars (which create pollution) or foods associated with high levels of greenhouse gases, while consequences include social reinforcement, punishment or monetary incentives (Lehman and Geller, 2004). The responses given to these discriminative stimuli produce positive consequences such as pleasure or a sense of status, which reinforce and maintain actions that harm the environment (Lehman and Geller, 2004).

*Hines, Hungerford, and Tomera's Model of Responsible Environmental Behaviour:* This model was developed as a quantitative synthesis of studies on environmentally responsible behaviour. They carried out a meta-analysis of the literature and identified three main factors involved in conservation behaviours: personality traits, knowledge and skills, and situational variables. Their definition of personality traits included the desire to act, attitudes, locus of control and personal responsibility (Osbaldiston, 2013). In the model, personality traits are insufficient to ensure action; knowledge of the environmental problem and capability to change behaviour are prerequisites (Hines et al., 1987). Situational variables, such as social pressure, economic constraints, or opportunities to choose different actions act as modulating factors that may either counteract or to strengthen the other variables in the model (Hines et al., 1987).

*Evolutionary psychology:* This approach views behaviours, and the psychological processes that influence them, as products of evolutionary adaptations (Workman and Reader, 2021). Evolutionary psychology conceives of unsustainable behaviour in relation to components of the natural environment as the result of a mismatch between the conditions that shaped humans' evolutionary history and modern day living conditions (Barrett et al., 2002). Evolutionary psychological literature argues that the psychological mechanisms that yield unsustainable environmental behaviours can also be used to encourage sustainable behaviour. It has been established that individuals display psychological mechanisms that support pro-sociality (e.g. altruism and equity) (Dickinson et al., 2013) and there is physiological evidence that specific brain areas relating to experience of pleasure and rewards are activated by altruistic behaviours (Moll et al., 2006). Evolutionary psychology aims to use similar physiological infrastructure to encourage sustainable pro-environment and pro-conservation behaviours, for example to design of Internet communities in such a way as to support environmental collective action (Dickinson et al., 2013).

*Cognitive theories:* This approach focuses on a prosocial or moral nature present in individuals (Corral-Verdugo et al., 2019). Well known examples include the Moral Norm Activation Model, which posits that people's behaviour is contingent on moral norms, which in turn are based on two cognitive requirements: 1) awareness of the consequences of one's behaviour on the wellbeing of other people, 2) the individual admits having some responsibility for the consequences of their acts (Schwartz, 1968). These two requirements are considered necessary for altruistic (or pro-conservation) behaviours to occur as they precede the activation of moral or personal norms (Herreros and Santiago, 2004).

*Steg and Vlek's four-step model for pro-environmental behaviour:* this model is the result of a comprehensive analysis of the conservation psychology literature. The authors identified four steps for encouraging pro-environmental behaviour: (1) identification of the target behaviour, (2) investigation of the factors underlying this behaviour, (3) design and application of interventions to

change behaviour, and (4) evaluation of the effects of these interventions (Steg and Vlek, 2009). For the purposes of this review of models for understanding behaviour, step 2 is most relevant. The authors identify weighing of costs and benefits, moral and normative concerns, affect, contextual factors, and habitual behaviours as key elements (Steg and Vlek, 2009).

*Value-belief-norm model:* Stern's Value-Belief-Norm model gives weight to the orientation of an individual's values, and acknowledges that they will have a direct influence on their beliefs, and consequently, on their attitudes and behaviour (Stern, 2000). The individual's values are seen as modulating the information that the individual evaluates and if the information is congruent with the individual's values, the person develops more positive beliefs towards that situation, object or action (Stern, 2000). The model also includes the activation of personal norms, which is dependent on the values of the individual, which can range from egoistic value-orientation to biospheric values. The value-belief-norm model draws causal relationships between its component variables which are argued to determine the ecologically responsible behaviours, for example the responsible behaviour of tourists (Landon et al., 2018).

*The Focus Theory of Normative Conduct:* This theory rests upon the centrality of the social group and social norms in shaping behaviour (Corral-Verdugo et al., 2019). Cialdini et al. (2006) argue that behaviour towards the environment is determined by perceived prescriptive and descriptive norms, each of which constitutes a normative reference group. The descriptive norm refers to what most people do in their environment, and the prescriptive norm refers to the values held by significant individuals, and what they expect from the individual in question. The Focus Theory of Normative Conduct predicts that the different categories of norms lead to different behaviours, and that the relationship between norm and behaviour is contextually dependent, with the norm that is most salient in the mind of the individual at the time of behaviour exerting the greatest influence (Stok and de Ridder, 2019). Both descriptive and prescriptive norms have been found to contribute significantly to explain why people refrain from illegal behaviours (Armitage et al., 1999).

*Motivational theories - Self-efficacy and Self-regulation:* these approaches assume that pro-environmental behaviours constitute deliberate actions shaped by the situation, the time, and the context in which they are carried out (Rodríguez and Ruiz, 2008). These theories argue that people who consider themselves as possessing "high control skills" tend to rely on their abilities to respond to environmental stimuli (Corral-Verdugo et al., 2019). Self-efficacy is one of such self-regulatory mechanisms, and refers to an individual's confidence in handling specific situations, which in turn reflects the individual's perceived degree of behavioural control (Bandura et al., 1999). Self-efficacy influences both thought processes and behaviour and is claimed to be an ideal predictor of the actions that people decide to become involved in (Bandura et al., 1999). In relation to behaviour towards the environment in general, and conservation specifically, theories based on self-efficacy provides a link between intrinsic motivation and the maintenance of sustainable behaviours. Community effectiveness is an extension of self-efficacy and refers to perception of the community's ability to perform behaviour (as opposed to that of the individual), and it has been observed that communities with higher degrees of perceived community effectiveness achieve a larger degree of changes in their surroundings (Sampson et al., 1997).

*The theory of affordances:* This theory is based on studying how the environment induces effective responses ."Effective" responses are those that generate a positive result for the individual (Gibson, 1979). "Affordances" refer to the possibilities that stimuli in the environment offer to the individual (or organism) as possibilities of action (Chemero, 2003). Natural resources offer a wide range of affordances, and it is therefore probable that a large portion of unsustainable behaviours will be provoked by action option responses since they offer the opportunity to benefit from these resources (Osbaldiston, 2013). The objective for conservationists becomes to design opportunities that generate pro-environmental behaviours, and Kaaronen (2017, p. 1) argues that "by adopting the theory of affordances as a guiding heuristic, environmental policy-makers are better equipped to promote policies that translate sustainable thinking into sustainable behaviour", which can lead to a

self-reinforcing process. *The theory of planned behaviour:* Attitude is often a strong predictor of intention to behave in a certain way (Fulton et al., 1996, Fishbein and Ajzen, 2011) and can therefore provide insights on people's willingness to coexist with wildlife (Carter et al., 2014). However, there is far from an automatic link between attitudes and actions (St John et al., 2010, Dickman and Hazzah, 2016). Heberlein (2012)maintains that factors outside the individual have strong influence on people's behaviour beyond the effect of internal factors such as beliefs, knowledge or emotion, which he terms the drivers of attitude. de Pinho et al. (2014)illustrates this with their study of the Amboseli ecosystem where positive attitudes towards the aesthetic appeal of megafauna species is overridden by political motivations for killing lions, elephants (*Loxodonta africana*) and buffaloes (*Syncerus caffer*). Ajzen's Theory of Planned Behaviour (TPB) states that the individuals' perceived behavioural control (ability to affect change) and social acceptability and expectation influences the intention to carry out a behaviour (which it is argued is the most proximal determinant of engaging in a certain behaviour) in addition to attitude (Ajzen, 1985). Several studies of human-carnivore interactions have found support for this. Marchini and Macdonald (2012) found that their theory of planned behaviour model explained twice as much variation in the intention to kill jaguars (*Panthera onca*) than the alternative model which was based on perceptions of jaguar impact on livestock and on human safety. St John et al. (2018) found that perceived behavioural control was the strongest predictor of intention to kill Sumatran tigers (*Panthera tigris sondaica*).

### 1.4.2. Choice of framework

Among these theoretical frameworks of conservation psychology, I chose to use the framework provided by the Theory of Planned Behaviour. I rejected behaviourist approaches as they hold the view that the object of psychology is behaviour (Skinner, 1965), and I argue that attitudes are important in their own right, not just as a means of predicting behaviour (section 1.4.3.IV and 1.4.4.). Approaches of evolutionary psychology provide an interesting way to approach lion conservation given the long evolutionary history shared between lions and people (Hart and Sussman, 2018),

however these approaches are not quite optimal for the purposes of this thesis because they have been developed for intervention design (Workman and Reader, 2021), and the purpose of this thesis was to understand the patterns of attitudes present in the population. Design of interventions would be the next step. The same applies to Steg and Vlek's four-step model for pro-environmental behaviour (Steg and Vlek, 2009), so this model would also not provide the most suitable framework for this thesis.

Cognitive theories (Corral-Verdugo et al., 2019), Stern's Value-Belief-Norm model (Stern, 2000) and The Focus Theory of Normative Conduct (Cialdini et al., 2006) would have been suitable as frameworks, but the TPB has the advantage of incorporating behavioural control in addition to social norms and the individual's own values. TBP incorporates social norms and individual's attitudes but also acknowledges limitations in the individual's ability to translate the norms of society and his/her own values into behaviour (Heberlein, 2012), which gives this framework some advantage over these theories. Similarly, motivational theories of self-efficacy and self-regulation would provide useful insights for the purposes of this thesis, but the TPB covers a wider range of factors. Motivational theories provide frameworks for detailed study of behavioural control and intrinsic motivation, but does not incorporate the social aspects of behaviour (Rodríguez and Ruiz, 2008).

The theory of affordances was not very suitable for this thesis because it centres on "effective responses" that generate a positive result for the individual (Gibson, 1979). This does not lend itself to studying predation events which are rare and unpredictable events, and where there are only partially observable consequences of killing lions. Furthermore, this theory does focus much on understanding attitudes, which I argue have value in itself, as opposed to purely focusing on behavioural outcomes. (Section 1.4.3.IV and 1.4.4).

Hines, Hungerford, and Tomera's Model of Responsible Environmental Behaviour would have been a suitable alternative to the TPB. It incorporates knowledge, skills and situational variables, which could encompass all the major components of TPB, and would likely give satisfactory results (Hines et al., 1987, Osbaldiston, 2013). However, the choice of model was also constrained by the available data (as explained in more detail below), and some key components of the Model of Responsible Environmental Behaviour were not recorded in the survey (such as the desire to act).

Among these frameworks, the TPB was particularly suitable because it encompasses a wide range of factors (including both social norms, behavioural control and attitudes) (Ajzen, 1985), and because it lent itself to the data that was available (section 1.4.3.). The TPB allows one to situate attitude (which constituted the focus of the analysis in chapter 3 due to the available data) within the chain of variables that determine actualised behaviour.

1.4.3. Reasons for the focus on the attitude component of the TPB

I. Limitations of the data. The focus of Chapter 3 in this thesis is on attitudes, as opposed to other psychological factors or behaviour itself. This choice was largely constrained by the structure of the available data, as the data that forms the basis of Chapter 3 was originally collected as control variables for the other analyses, but proved to be substantial enough to support a chapter on its own.

II. Attitudes contributes to understanding behaviour as part of the TBP. Attitudes are an important component for understanding behaviour as part of the TPB and this thesis therefore elucidates one of the key components required to understand behaviour (in this case, the behaviours of interest are those that are conducive/inconducive to coexistence with lions, such as lion killing). However further studies would be required to accurately predict behaviour as part of the TPB, as this study only elucidates the attitude component.

III. Often attitudes alone predict behaviour well (Dickman and Hazzah, 2016, St John et al., 2011, Broekhuis et al., 2018). For example mongst Kenyan Maasai, attitudes towards lions

was the strongest predictor of the behaviour of interest: actual lion-killing behaviour (Hazzah et al., 2017). Another study in the Maasai Mara found that the behavioural intention to kill carnivores was only influenced by the respondents' attitude (Broekhuis et al., 2018). In some cases, antagonistic behaviour towards wildlife is symptomatic of human-human conflict over different issues where wildlife becomes symbols of social divisions (Skogen and Krange, 2003, Song, 2000), such as in Norway where carnivore conservation becomes a symbolic resistance point by rural communities against the perceived expansion of the urban elite (Skogen et al., 2013). In such cases the Theory of Planned Behaviour falls short as the resistance to carnivores does not relate to norms, behavioural control or attitudes to carnivores, but instead is a protest behaviour in response to unrelated social processes. However, this shortcoming does not affect the present work as the focus is on attitudes not actualised behaviour.

IV. Attitudes are important in themselves. A further reason for not focusing on behaviour was that though attitude is a crucial component of predicting behaviours that are conducive/inconducive to coexisting with lions, this thesis investigates attitudes not only to predict a specific behaviour. Attitudes to coexistence is likely to affect a wider range of behaviour than just lion killing, such as hostility towards lion conservation organisations, national park management and public support for conservation policies. The choice was therefore made to focus on attitudes to coexistence rather than behavioural intention (which enforces a more narrow focus on specific behaviours), and to aim to achieve a nuanced and detailed examination of the predictors of attitudes to coexistence. Furthermore, the attitudes of the people who live alongside carnivores are not only of interest in order to achieve conservation goals, but also for their own sake (further details outlining this rationale for the focus on attitudes can be found in section 1.4.2. below).

### 1.4.4. Aims of the attitude analysis

This work has the dual aim of A) informing effective conservation efforts and B) understanding the viewpoints of the communities for their own sake. The second aim of this investigation of attitudes to coexistence with lions is of equal importance and relates to issues of environmental justice (Jacobsen and Linnell, 2016, Lecuyer et al., 2019). Gore and Kahler argue that "failing to engage groups who are affected by and have the potential to affect environmental risks, such as human-wildlife conflict (HWC), would not only represent a missed opportunity for a more effective risk resolution, but also an abuse of power and degree of negligence on behalf of decision makers tasked with managing risks." Attitude is of interest not just as an instrument to achieving conservation aims, but also to understand the impact lion presence is having on the local communities and to achieve a non-homogenous picture of their view on living with lions. The recognition of stakeholders' identities and viewpoints has been shown to be an integral part of environmental justice for stakeholders in carnivore management, in some cases of equal importance to participation in decision-making and equitable distribution of costs and benefits (Jacobsen and Linnell, 2016). To illustrate, a focus on behavioural intention as prescribed if following the full TPB framework towards predicting behaviour, would in the case of these communities likely lead us to focus on the behaviour of young and middle aged males, as they are empowered/tasked with carrying out lion killing behaviour. Meanwhile, women could conceivably be suffering more from lion presence due their higher level of physical vulnerability but have little behavioural intention to act accordingly.

### 1.4.5. The attitude construct

The attitude construct performs a central role in the field of social psychology including environmental psychology (Kansky et al., 2014). Attitude has been defined in a variety of ways, but definitions have the commonality that attitudes are evaluations or feeling states , which might be related to something physical, such as lions, or something intangible such as particular social issues

or situations (Browne-Nuñez and Jonker, 2008). In this paper, I will use attitude as defined by Kansky et al. 2014, based on the work of Fishbein and Ajzen (2010): "Attitudes can be defined as a disposition or tendency to respond with some degree of favorableness, or not, to a psychological object, the psychological object being any discernible aspect of an individual's world including an object, a person, an issue, or a behaviour" (Kansky et al., 2014). This corresponds closely to how the attitude concept is used in much of recent literature on human-wildlife interaction (Gebresenbet et al., 2018b, Andreassen et al., 2018).

1.4.6. Review of the literature on the factors that influence attitudes towards carnivores

Qualitative and quantitative work have identified factors that are associated with more or less positive attitudes towards carnivores. Not all factors are significantly associated with attitude in all contexts, and the effect of a significant variable is not necessarily in the same direction (the effect might be positively associated with attitude in one context and negative in another location or conflict). Several types of variables have been demonstrated to be of significant effect and are presented in categories below. Many of the categories overlap conceptually, and there are several equally defensible ways to categorise the factors in question. The different categories are certainly likely to interact and the significance of one of these in a study cannot be ruled out to be due to collinearity with a true causative variable in another category. What follows is a classification for convenient communication, as best can be achieved without empirical evidence available to tease apart collinearity and causation.

i. Religion, spirituality and traditional beliefs:

Cultural value/disvalue attached to carnivores can contribute to positive or negative attitudes. Leopards (*Panthera pardus*) have a central position in Samburu folklore (Kenya) and Mitchell et al. (2019) posit this as part of the explanation for why attitudes to leopards were more positive than

would be predicted based on predation frequency. The communities on the border of Manyeleti Game Reserve, South Africa, consider lions part of their cultural heritage, and this contributes to positive attitudes and coexistence (Lagendijk and Gusset, 2008). In Kafa, (Ethiopia), there is a "culture of tolerance" with traditions of respect towards lions and belief that losing livestock to lions heralds good luck and wealth (Gebresenbet et al., 2018a). Such cultural value can vary on relatively fine spatial scales; in the area of Gambella National Park in Ethiopia, 73% of respondents attached no cultural value to lions (Gebresenbet et al., 2018b) in contrast to the culture of tolerance in the Kafa area (Gebresenbet et al., 2018a). Cultural associations of wildlife can also have negative effects on attitudes, for example the belief in spirit lions that can be used to harm people (Dickman, 2010).

Religious beliefs and affiliations have been shown to be powerful predictors of attitudes to carnivores in several contexts (Dickman et al., 2013). Christian beliefs were found to be associated with negative views of wildlife in Kenya (de Pinho et al., 2014), with evangelical branches of the religion being particularly negative (Hazzah et al., 2009). However, religious beliefs are not uniformly associated with negative attitudes to carnivores. Religious beliefs have been found to be positively associated with attitudes in several contexts. For example, in Manang (Nepal), Buddhists consider the snow leopards (*Panthera uncia*) sacred (Ale, 1998). In Bardia National Park (Nepal), religious beliefs were associated with more positive attitudes to tigers, and tigers (*Panthera tigris tigris*) are culturally linked to the goddess of might (Bhattarai and Fischer, 2014). Tolerance of Sumatran tigers has been linked to both Islamic hunting prohibitions and indigenous beliefs (McNeely and Sochaczewski, 1995, Boomgaard, 2008, McKay et al., 2018), and Struebig et al. (2018) found that one of the most important factors associated with tolerance for tigers was the perceived importance of tigers for spiritual wellbeing (Struebig et al., 2018).

ii. Social factors:

Within society, an individual's position and societal expectations, punishments and rewards have been shown to be influential on attitudes towards carnivores. Social status has been found to be influential; Carter et al. 2014 found people from marginalised groups to be more negative to tigers (Carter et al., 2014) and Hariohay et al. (2018) found that immigration status was an important factor in determining attitudes to wildlife, with more negative attitudes found among immigrants. These findings may have their root in the enhanced economic vulnerability of marginal social groups. When it comes to behaviour, it has been demonstrated in several locations that anti-carnivore behaviours can be motivated by social factors. Inskip et al. (2014) found that increasing social status was part of the motivation for killing tigers in the Sundarbans in Bangladesh, and in Tanzania, ritual lion killing increases young men's social status and give social rewards such as cattle and increased access to women (Dickman, 2010). These are behavioural outcomes not attitudes, but there is evidence that social rewards also have an effect on underlying attitudes. Some Maasai are positive to the continued presence of lions due to the role of lions hunts in proving themselves and gaining status (Goldman et al., 2010). Group identity can also play a role in shaping attitudes when holding certain attitudes to carnivore is itself an act of confirming belongingness to a social group and to the active construction of community, such as in the highly polarised conflict around carnivore management in Norway (Skogen and Krange, 2003).

iii. Emotional responses:

Somewhere in the intersection of culture, personality and biology, lies an influential set of variables related to emotional responses to carnivores. Instinctual dread towards carnivores has been interpreted as remnants of a prey response shaped by millions of years of hominid evolution (Kruuk, 2002). Fear is a recurring important predictor of attitude (Prokop et al., 2009), with examples ranging from jaguars in Brazil (Marchini and Macdonald, 2012) to carnivore guilds in South Africa

(Lagendijk and Gusset, 2008), though it is not always so, e.g. (Zimmermann et al., 2001). On the other hand, countervailing forces of aesthetics and charisma can provide positive emotional responses. Attitudes to tigers have been found to be positively influenced by the participant's perception of tigers as beautiful (Bhattarai and Fischer, 2014). Large carnivores, in particular big cats, score highly in terms of perceived charisma in many cultural contexts (Macdonald et al., 2015) , though by no means in all – big cats scored low in ratings of charisma among Zimbabwean subsistence farmers (Macdonald et al., *in prep*). Perceived beauty/ugliness were the strongest variable influencing the support for removal of a series of species in a study of Kenyan agropastoralist communities such as lions and hyenas (de Pinho et al., 2014). Emotional responses in the form of instantaneous affective responses were among the most influential variables driving tolerance of tigers in a socio-ecological model (Struebig et al., 2018).

*iv.* Demographic variables:

Variables, such as gender, age, family size, marital status etc., are often thought to influence attitude towards wildlife in numerous ways, including vulnerability to human-wildlife conflict situations (Hill, 2004). The evidence is mixed, with certain demographic variables being influential in some situations, while in other contexts no significant effect of demographic variables have been found. Romanach et al. 2007 found no influence of such variables on attitudes to lions, cheetahs, spotted hyenas, leopards and jackals in Kenya (Romanach et al., 2007), and a meta-analysis by Kansky and Knight (2014) found that socio-demographic variables overall poorly explained attitudes towards large mammals in conflict. However, this is context dependent. There is robust evidence from many locations that attitude varies by gender, with women typically being more negative to large carnivores (Suryawanshi et al., 2014, Bhattarai and Fischer, 2014, Campbell and Lancaster, 2010, Fort et al., 2018, Gebresenbet et al., 2018b). In a study of Kenyan agro-pastoralist communities, being female was the strongest factor contributing to support for lion removal (de Pinho et al., 2014). However, though women generally rate carnivores as more dangerous, this does not always

translate into more negative attitudes towards coexisting with those species. In British Columbia, women were found to be more fearful and negative towards pumas but were less likely to support shooting of pumas (*Puma concolor*) (Campbell and Lancaster, 2010), and similar results were found in Lithuania in regards to lynx (Balčiauskienė and Balčiauskas, 2001). Other studies have found non-significant effects of gender on attitudes to carnivores (Hariohay et al., 2018, Ogra, 2008).

Age is another demographic variable that has been found to be associated with attitude in a context-dependent manner. Age has been shown to have both negative (Suryawanshi et al., 2014, Røskaft et al., 2007, Campbell and Lancaster, 2010, Zimmermann et al., 2005, McKay et al., 2018) and positive (Tessema et al., 2010) association with attitude to carnivores. Hariohay et al. (2018)found a curved relationship between attitude to wildlife conservation and age, with respondents aged between 27 and 55 being most positive. However, when there is a significant effect of age, the general trend seems to be that usually younger people have more positive attitudes to carnivores and their presence and are less positive about removal or killing, e.g. Hariohay et al. (2018), Zimmermann et al. (2005), Jacobsen et al. (2020) and (Suryawanshi et al., 2014).

Level of education has frequently been found to be associated with attitudes towards carnivores and other potentially dangerous wildlife. This has been found for tigers (Carter et al., 2014, McKay et al., 2018), lions (de Pinho et al., 2014, Gebresenbet et al., 2018b, Romanach et al., 2007), leopards (Romanach et al., 2007), jaguars (Fort et al., 2018), snow leopards (Suryawanshi et al., 2014) and jackals (Romanach et al., 2007). In fact, education had the greatest influence of people's attitudes to wolves (*Canis lupus*), golden jackals (*Canis aureus*), red foxes (*Vulpes vulpes*), striped hyaenas (*Hyaena hyaena*), caracals (*Caracal caracal*), leopards, and wild cats (*Felis sylvestris*) in Isfahan province in Iran (Behmanesh et al., 2019). The most common finding is that positivity towards carnivores increase as educational level increases, though it is culturally dependent (e.g. Carter et al. (2014), McKay et al. (2018) de Pinho et al. (2014), Gebresenbet et al. (2018b), Romanach et al. (2007), Romanach et al. (2007), Fort et al. (2018), Suryawanshi et al. (2014), Romanach et al. (2007)).

More educated Maasai tend not to support traditional lion hunts, a tradition that is linked to positive attitudes to lions (de Pinho et al., 2014).

*v.* Other demographic variables have also been found to occasionally be associated with attitudes to large wildlife. Family size influenced attitudes positively in a study in Ethiopia of attitudes to wildlife and protected areas (Tessema et al., 2010). In the Maasai Mara, attitudes towards predators were dependent on the occupation of the respondent amongst other factors (Broekhuis et al., 2018). Wealth and ownership of resources:

Measures of wealth, in terms of monetary income or livestock and crops, are expected to influence attitudes to species involved in conflicts because wealth influences the individuals' ability to absorb damages occurred (Naughton-Treves and Treves, 2005). Wealthier ranchers held more positive attitudes to jaguars in the Pantanal (Zimmermann et al., 2005) and monthly income was one of the two most important variables for explaining attitudes to conservation of protected areas in Bangladesh, with poorer people having more negative attitudes (Sarker and Røskaft, 2011). Livestock are a major source of wealth in many countries, but it is problematic to make conclusions based on livestock wealth when studying carnivores as there is conflation between livestock holdings as wealth indicator and as a cause of increased vulnerability to conflict damage. This conflation is not adequately acknowledged in the literature. Wealth on a national scale could conceivably also affect attitudes, and the meta-analysis by Kansky et al. (2014) found that the development status of a country was statistically significant, but of relatively low importance in determining attitudes towards damage-causing mammalian wildlife (Kansky et al., 2014).

However, it is not only wealth in absolute terms that may influence attitudes; ownership of resources, both in terms of the diversity of accessible resources and the security of ownership of resources, have been shown to be influential on people's attitudes to carnivores in some contexts.

Diversity of income sources was part of the model that best explained attitudes to wolves among pastoralists and displayed a positive relationship with attitude (Suryawanshi et al., 2014). Similarly, diversified income sources had a positive relationship with attitudes to wildlife among some Ethiopian communities (Tessema et al., 2010). Land ownership was associated with positive perceptions of jaguars among residents living near national parks in Panama (Fort et al., 2018), and the legal status of the land has been found to be overall an important factor, with greater legal security being associated with more positive attitudes (Kansky and Knight, 2014, Romanach et al., 2007).

vi. Stakeholder type:

This category has been found to be a key factor in driving attitudes to large mammals (Kansky and Knight, 2014), with urban residents expressing the most positive attitudes towards large mammals, followed by commercial farmers, and the most negative attitudes held by communal farmers (Kansky et al., 2014, Romanach et al., 2007). This category might be representing a range of underlying variation in wealth, land security, risk of damage, education and social capital among these groups, and so is useful for pragmatically targeting conservation policies, but less so for uncovering the causes of attitudes to conflict species.

vii. Value orientation:

Values, as defined by (Schwartz, 2005), constitute desirable goals that express the basic needs and guiding principles in people's lives. Different value orientations have been implicated in the attitudes held towards wildlife in general and carnivores specifically. Fulton et al. (1996) developed a theory of wildlife value orientation that builds on the applied cognitive hierarchy framework. They argued that behaviour towards wildlife is driven by specific attitudes, and that these attitudes are guided by wildlife value orientations. They placed participants on a value axis of domination-mutualism and

found evidence that such orientation produces different attitudes towards wildlife, with more mutualistic orientations being associated with more positive attitudes towards wildlife and conservation (Teel et al., 2010). The “wildlife protection” – “wildlife use” dimension has proven strongly associated with attitudes to wildlife management proposals (Manfredo and Dayer, 2004). This continuum is also commonly conceptualised as an “ecocentric”- “anthropocentric” axis (Andreassen et al., 2018). Bjerke and Kaltenborn (1999) found a positive association between ecocentric motives and positive attitudes to large carnivores, and a negative relationship between anthropocentric motives and negative attitudes (Bjerke and Kaltenborn, 1999).

viii. Risk perception and experience:

The perception of risk posed by carnivores has been found to be a predictor variable of attitudes. Inskip 2014 found that risk perception contributes to motivating people to kill tigers (Inskip et al., 2014). Past experiences with the species in question, such as encountering the animals or observing spoor or vocalisations, has also been shown to be associated with attitudes (Kansky and Knight, 2014). These two variables are closely connected, as experiences with carnivores may influence your perception of risk so they are not easily separable and will be treated together in this section. There is plausible logic for both positive and negative effects of experience on attitude. Encountering carnivores could lead to more negative attitudes due to increased risk perception. The likelihood of having encountered a tiger in the past, which the authors of the study interpret as risk perception informed by past events, was a driver of tolerance of tigers (Struebig et al., 2018). Risk of actual attack, as determined by an ecological model, was also significant in predicting tolerance to tigers (Struebig et al., 2018). Struebig et al’s study used tolerance rather than attitude as their response variable, but their phrasing of the question, in terms of preferences for the tiger population to be eradicated/reduced/increased populations, means that the results are comparable to questions gaging attitudes to coexistence. I would argue that when studying the effect of experience in human-wildlife coexistence, second-hand experiences should also be included as a valid form of experience.

Communication between individuals and communities mean that people "retain fact and fiction from past generations, alleged and real catastrophic events can shape perceptions for decades and spread across broad regions" (Sillero-Zubiri et al., 2007). Experience with carnivores could also be hypothesised to have a positive effect on attitudes by increasing familiarity,confidence and by invoking positive emotions from viewing wildlife in their natural environment (van der Meer and Dullemont, 2021).

It is not just magnitude of perceived risk that is influential but is also the nature of the risk: including the type of harm, responsibility and novelty of the risk (Dickman, 2010). Starr (1969) showed that people were on average 1000 times more likely to accept risks that they choose to undertake compared to risk that are externally imposed, and Fischhoff et al. found that the most important drivers of tolerance for risk in regards to technology was the level of intrinsic dread and the novelty of the risk (Fischhoff et al., 1978). This is highly relevant to carnivores as they tick all the boxes of heightened risk perception: they are often associated with the policies of governments and conservation organisations (Skogen et al., 2013, Naughton-Treves and Treves, 2005), are capable of instilling a high level of dread (Kruuk, 2002), and in many places are recovering from historically low numbers and are can therefore be perceived as a novel risk (Zimmermann et al., 2001).

ix. Tangible costs and benefits:

Carnivores' presence can entail a range of tangible costs, such as loss of livestock, the cost of herding (Herrmann et al., 2001) and other predation avoidance behaviours (Barua et al., 2013), and tangible benefits, such as economic value through trophy hunting fees (Macdonald et al., 2017a), tourism (Hemson et al., 2009) or benefits generated by conservation programmes (Sillero-Zubiri and Laurenson, 2001). Tangible costs/benefits, such as livestock loss, does not imply only material ramifications – in rural societies, loss of livestock can mean a loss of social status (Dickman and Hazzah, 2016). These costs and benefits are usually hypothesised to affect attitudes, though the

evidence is mixed: they have been found to influence attitudes in some locations and situations, while in others not. Incidents of conflict or numbers of livestock loss has been found to be significantly associated with negative attitudes towards carnivores in a number of locations, including Ethiopia (Tessema et al., 2010, Gebresenbet et al., 2018b), Nepal (Bhattarai and Fischer, 2014), Tanzania (Holmern et al., 2007) and Brazil (Marchini and Macdonald, 2018). However, a large number of studies have found no significant effect of livestock loss or conflict intensity with a range of large carnivores such as wolves, jaguars, lions, tigers, leopards and snow leopards (Porfirio et al., 2016, Treves et al., 2013, Suryawanshi et al., 2014, Broekhuis et al., 2018, Gebresenbet et al., 2018a, McKay et al., 2018). However, the effect of predation on attitudes towards carnivores depends not only on time and place, but also on the species involved. The same individuals can respond differently to predation frequency depending on the species of carnivore involved. Mitchell et al. 2019 found that attitudes towards spotted hyaenas (*Crocuta crocuta)* and lions were proportionate to predation incidents, while community members held positive attitudes towards leopards despite their high involvement in conflict, and held negative attitudes to African wild dogs (*Lycaon pictus*) regardless of their low involvement (Mitchell et al., 2019). Loss of human life however, is unsurprisingly consistently associated with negative attitudes (Naughton-Treves and Treves, 2005, Sillero-Zubiri et al., 2007, Carter et al., 2014).

The evidence for the effects of tangible benefits on attitudes towards carnivores is also mixed. Lack of benefits from conservation has been linked to negative attitudes to wildlife among rural people in Zimbabwe (Matseketsa et al., 2018), perceived benefits emanating from a national park were given as reason for positive attitudes towards tolerating tigers in Indonesia (McKay et al., 2018), and in central Kenya people with more income from wildlife tourism expressed more tolerant attitudes towards carnivores (Romanach et al., 2007). There are also cases of counterintuitive results: economic benefits from wildlife had negative effect on attitude to lions among agropastoralist communities in Kenya (de Pinho et al., 2014). In their analysis of published studies on factors driving

attitudes to large mammals in conflict with humans, Kansky et al. (2014)found that tangible costs and benefits were respectively two and three times more non-significant than significant.

*x.* Intangible costs and benefits*:*

These are impacts that are not mediated through the loss/gain of something physical. Carnivore presence can entail intangible costs, including emotional and psychosocial harms, such as fear and stress, and intangible benefits such as existence value or pleasure from seeing the animals (de Pinho et al., 2014, Barua et al., 2013). The meta-analysis by Kansky and Knight (2014) found that though intangible benefits were mostly unimportant in explaining attitudes, intangible harm was the most important category in explaining attitudes (Kansky and Knight, 2014). Despite this, this category was underrepresented in literature (Kansky and Knight, 2014). Intangible harms are a key focus throughout all chapters of this thesis.

xi. Wildlife management and conservation policies:

Attitudes to wildlife can be coloured by attitudes towards the management of wildlife and protected areas. Good relations with protected area staff (Tessema et al., 2010) and perceived ownership of predators (Broekhuis et al., 2018) has been found to influence positive attitudes to wildlife. Perceived failing of local authorities to prevent tiger incidents, which villagers believed to be the responsibility of the authorities, contributes to motivation for tiger killing (Inskip et al., 2014). Similarly, hostility to elephants was intensified by general resentment of conservation authorities in Uganda (Naughton-Treves and Treves, 2005). Participation in conservation programmes has been linked to positive attitudes in several locations e.g. (Kideghesho et al., 2007, Broekhuis et al., 2018), but this effect is not universal (e.g. (Macura et al., 2016)).

xii. Symbolism:

The categories that have been discussed so far have been closely related to the effects of carnivore presence. However, attitudes to carnivores can be affected by issues that are unrelated to carnivore presence, where resistance to the species in question is symbolic of an underlying human-human conflict about other issues (Dickman, 2010). In-depth sociological analysis of negative attitudes to carnivores in Norway established that such negative attitudes partly result from resistance to the urban elite and to central governmental influence, of which the wolf becomes a symbol (Skogen et al., 2013). In Kenya, lions were killed in Nairobi National Park because of resentment towards the government (Dickman and Hazzah, 2016). Similar dynamics have been observed to contribute to hostile attitudes and actions towards non-carnivorous conflict species: monkeys have been killed by farmers in Japan to dissipate anger towards the government defunding rural development schemes (MAITA, 1989), and pigeon shoots in the United States have been motivated by the symbolic association of pigeons *(Columba livia domestica*) with urbanity and moral decay (Hoon Song, 2000).

### 1.4.7. Terminology

The term “human-wildlife conflict” has received criticism on the grounds that the word “conflict” defines the interactions between humans and wildlife as antagonistic, and it is argued that “human-wildlife interactions” provides a more suitable term (Frank et al., 2019). In this thesis, I will use the term “human-wildlife interaction” when referring to the wider field, and “human-wildlife conflict” when referring to the subset of the field that deals with antagonistic relationships between humans and wildlife. The latter is the most relevant to the interactions between humans and lions in the study site that is the focus of this thesis. A further criticism of the term “human-wildlife conflict” is presented on the grounds that the term obfuscates what is actually human-human conflict over issues involving wildlife (Redpath et al., 2015), as touched upon in section 1.4.4 of this thesis. Though human-human conflict over lion management is very much a part of the conflict dynamics at the study site that is the focus of this thesis, I have elected to use the term “human-wildlife conflict”

to be consistent with the majority of the body of literature, and because concrete conflicts between humans and lions are also part of the conflict dynamics at the study site.

Previous research has identified factors that are associated with more or less positive attitudes towards carnivores, coexisting with carnivores or carnivore conservation. These are related but non-identical concepts, but the literature rarely, if ever, discusses or considers the difference. There is inadequate recognition that attitude towards a carnivore may not be the conservation-relevant variable – for example, you might be feel very positive to wolves as long as they live somewhere far away. In this thesis, the concepts of attitude towards the carnivore species itself and attitude to coexisting with the carnivore in the same area will be treated as separate.

## 1.5. Part 2: Quantifying the total value of the marginal lion through choice experiments

Studies of attitudes to carnivores indicate that both material and intangible factors are likely to be influential in shaping willingness to co-exist with large carnivores. The material costs of living alongside large carnivores, both direct costs such as the value of depredated livestock (Holmern et al., 2007) and indirect costs such as herding (Herrmann et al., 2001) and buying fences (Schumann et al., 2006) are well understood. However, the intangible costs and benefits associated with living alongside carnivores have frequently been identified (Barua et al., 2013) (though even more often ignored) but not quantified. Economic valuation studies focusing on carnivores have only estimated the total value, not isolated the proportion of value attributable to intangible costs and benefits. Such intangible costs and benefits include harms such as emotional harms, for example fear and stress, and benefits such as existence value, or enjoyment from seeing wildlife (de Pinho et al., 2014). Understanding the full costs and benefits associated with living alongside wildlife is likely to be important to mitigating such conflict – though intangible costs are not observable they nonetheless may strongly influence stakeholders' attitude and behaviour. People with higher levels

of fear of carnivores where found to have more negative attitudes to carnivores, and people with more negative attitudes were also more in favour of having carnivores eradicated (Røskaft et al., 2007). There have been repeated calls for research to elucidate these unobservable harms (Thirgood et al., 2005, Macdonald and Loveridge, 2010, Barua et al., 2013). It is also important to understand how the costs of large carnivores balance against the benefits they generate. Many stakeholders appreciate that large carnivores generate tourism revenue (Ghosh and Uddhammar, 2013) and a range of intangible benefits have also been recorded, including cultural value, symbolic value and bequest value (Chambers and Whitehead, 2003). It is difficult to envision effective alleviation of conflict without understanding the full scope of harms and benefits people experience, and how that influences their attitudes and behaviours. If the costs of coexisting with wildlife outweigh the benefits, people are likely to take actions which may threaten wildlife populations (Dickman, 2009). We need a complete cost-benefit estimate of carnivore presence in order to effectively conserve them. Economic valuation techniques can be used to achieve this.

There are several alternative methods of estimating economic value and disvalue (negative value). Value can be estimated based on revealed preferences in real-life markets or through preferences revealed through hypothetical contingent markets (Dolan and Metcalf, 2008). However, revealed preference data is not available for a range of variables that are of interest to policymakers and researchers. Most public goods do not have markets (Levinson, 2012), as is the case with the public "bad" of lions from the perspective of the villages around Hwange National Park. Stated preference techniques avoid this complication as relevant data is generated through questionnaires. Choice experiments are a well-established method for that purpose. This method allow us to estimate the value of the marginal lion, which represents the sum of negative and positive values that the participants perceive as arising from each additional lion in their village area. This sum can be net negative or net positive, depending on whether positive or negative values predominate.

Choice experiments provide a method for quantifying the full range of costs and benefits associated with carnivores, including the seemingly unmeasurable intangible costs and benefits (Bennett and Adamowicz, 2001).

### 1.5.1. Past work on carnivores and economic valuation

The central concept of economic value is that it measures the change in wellbeing that arises from a good or service (or disservice) (Bateman et al. 2002). Maintenance of large carnivores in protected areas can be seen as such a service/disservice. Economic valuation techniques have been applied to large carnivores but there are clear patterns to which areas and species have been subject to non-market valuation, and there are large knowledge gaps. The majority of valuation studies have been carried out in Scandinavia relating to wolves, lynx, wolverines and bears (Boman and Bostedt, 1999, Boman et al., 2003, Ericsson et al., 2007, Broberg and Brännlund, 2008, Bostedt et al., 2008, Ericsson et al., 2008, Broberg, 2010, Håkansson et al., 2011, Johansson et al., 2012, Lind and Hundsnes, 2015). A few studies have also been carried out in the US, mainly looking at wolves (Jorgensen et al., 2001, Chambers and Whitehead, 2003). The remaining few studies are scattered around the world: UK (Macmillan et al., 2001, Morse-Jones et al., 2012), Poland (Bartczak and Meyerhoff, 2013), Sri Lanka (Wickramarachchi and Gunawardena, 2012), South Africa (Van Tonder et al., 2013, Di Minin et al., 2013), Namibia (Sutton et al., 2002), and South Korea (Han and Lee, 2008), looking at lynx, leopards, lions and bears, predominantly among rural communities.

The range of study species is even more narrow than the geographic range within the carnivore valuation studies. The North American research (Jorgensen et al., 2001, Chambers and Whitehead, 2003) focuses on wolves, which have also been the subject of several valuation studies in Scandinavia alongside lynx (*Lynx lynx*), wolverines (*Gulo gulo*) and brown bears (*Ursus arctos*) (Broberg, 2010, Broberg and Brännlund, 2008, Bostedt et al., 2008, Håkansson et al., 2011, Ericsson et al., 2008, Johansson et al., 2012, Lind and Hundsnes, 2015). I know of only four attempts to

estimate non-use values of African carnivores. Van Tonder et al. 2013 investigated the relationship between the characteristics of tourists on wildlife holidays and willingness-to-pay (WTP) for seeing lions and leopards. Di Minin et al. (2012) similarly studied the preference of tourists for big game species, and Van der Meer et al. (2016) estimated WTP for flagship species among tourists in Zimbabwe. Morse-Jones et al. (2012) investigated WTP for wildlife conservation (including lions) among distant beneficiaries among the general public in the UK.

Another limitation of carnivore valuation studies are that most do not allow for negative WTP and therefore do not capture the value attached to carnivores in areas where the net value of carnivores is perceived to be negative, such as is the case in areas with severe human-wildlife conflict. Sutton et al. (2002) investigate WTP among communities that live alongside carnivores in Namibia and does allow for negative WTP values, however they estimate general values for predator attack, and do not estimate values for particular species of carnivores. Furthermore, they do not estimate total value or harm associated with predator attacks, as psychological costs are not included. I provide the first total value estimate for lions from the perspective of the communities that live alongside them.

## 1.6. Part 3: The science of happiness: wellbeing research

A great number of the variables that have been shown to be associated with attitudes have also been shown to have a statistical relationship (and hypothesised causal relationship) with the wellbeing of people (the meaning of wellbeing will be discussed below).

In the HWC field, it is common to study the impact of HWC on people in terms of economic losses, impacts on health, time costs and access to opportunities, because all of these affect people's wellbeing. The assumption is that people aim to maximise their wellbeing (Deci and Ryan, 2000) and will object to wildlife only so far as their wellbeing is being compromised. Therefore, reducing the impact of carnivores on wellbeing is thought to reduce hostility to the species of wildlife in question,

or towards conservation initiatives in general (Woodhouse et al., 2015). This belief is not likely to be true in every context, as many cases of HWC are underpinned by social conflicts, and in some cases may be unrelated to the levels of harm caused by wildlife (Dickman, 2010). However, some level of harm is usually at least component of HWC so understanding the negative and positive impacts of wildlife on people's wellbeing is likely to be useful for mitigating conflict. I argue that instead of studying the effect of wildlife on proxies of human wellbeing (such as economic and social indicators), studying wellbeing directly provides a more direct investigation of the end goal. Furthermore, conflict mitigation is not the only motivation for understanding the impact of wildlife on wellbeing – safeguarding human wellbeing is a goal in itself (Woodhouse et al., 2015). Subjective wellbeing (SWB) methods can be used for that purpose, providing information for policymakers by elucidating the determinants of wellbeing (Conceição and Bandura, 2008).

### 1.6.1. Terminology

The field of SWB research is sometimes referred to as the "science of happiness" and it aims to not only measure happiness, but also to identify the factors that affects it and quantify their relative importance (Ballas and Tranmer, 2012). The terms "happiness" and "wellbeing" are often used interchangeably in the literature, but as there is no consensus of what "happiness" means the emerging consensus in the field has moved towards using the term "wellbeing" (Conceição and Bandura, 2008). This is the term that will be used throughout this thesis and refers to subjective wellbeing, as measured through self-assessed life satisfaction.

### 1.6.2. The integration of wellbeing research into policy

Subjective wellbeing methods are nested within the wider field of wellbeing. Wellbeing has increasingly come into focus as a policy-objective and a metric for progress and has been one of the fastest growing research fields (Chen et al., 2019). Traditionally, wellbeing had been considered

measurable by a single metric for policy purposes: Gross domestic product (GDP). However, it is now accepted that GDP provides an inadequate metric, as wellbeing is "multidimensional, encompassing all aspects of human life" (Conceição and Bandura, 2008). The emergence of wellbeing as an important component of development was rooted in the Human Development Index, which established a first step towards a more "holistic evaluation of the human condition", incorporating indicators of education, health and material living conditions (Agarwala et al., 2014). The scope of wellbeing has since expanded, much due to the influence of writers on poverty and development, to include entitlements (Sen, 1981), the natural environment (Dasgupta, 2001), vulnerability and social relations (Adger and Winkels, 2014). The developments in the field of wellbeing have led policymakers to redefine what it means to be successful as a society (Chen et al., 2019). Wellbeing has become a national policy objective in Bhutan, Ecuador, Bolivia, Chine, Italy, Germany, Brazil and the UK (Agarwala et al., 2014). The concept of wellbeing has been used to construct national assessments, localised studies, cross-country data sets for international comparisons (Beauchamp et al., 2018) and for comparisons of wellbeing at different time points (Santika et al., 2021) .

### 1.6.3. Wellbeing and conservation

Conservationists are concerned with human wellbeing for both pragmatic and ethical reasons (Woodhouse et al., 2015). Among the motivations is to gain legitimacy in the eyes of donors and governments, but also in the eyes of local stakeholders as conservation outcomes are often more successful if people's views and needs are taken into account, and because improving outcomes for people is often a goal alongside biodiversity goals (Milner-Gulland et al., 2014). This is part of an effort to move beyond narrow monetised approaches to assessing the impact of conservation, with ethical implications when conservation actions impact people who are poor, vulnerable or disempowered (Milner-Gulland et al., 2014), which is the case for the Zimbabwean communities that are the focus of this thesis. Woodhouse et al. (2015) argue that understanding, and working to improve, the impact of conservation on the multiple dimensions of people's lives is an ethical

imperative for conservation practitioners. The negative impacts of conservation on human lives can be serious, such as human-wildlife conflict, but can also entail loss of access rights and eviction from protected areas (Bottrill et al., 2014).

Woodhouse et al. (2015) further argue that there is insufficient evidence on the components of wellbeing to capture the complexity on the ground, and that though there is consensus in the environmental literature that empirical evaluation is required to determine what conservation methods work for biodiversity, this principle is rarely extended to the impacts on people's wellbeing. The responsibility that conservationists have to ensure that, at the very least, they cause no harm to people is established by policy commitments such as the Durban Accord on protected areas (Beauchamp et al., 2018) and USAID's Biodiversity Policy (Bottrill et al., 2014).

### 1.6.4. Operationalising wellbeing

Beauchamp et al. (2018) point out that despite the popularity of the term "wellbeing", it is rarely defined or examined empirically in the conservation field. Chapter 5 in this thesis presents an empirical examination of wellbeing, with a quantitative measure of subjective wellbeing as the metric. With the developments in wellbeing research, it has become clear that the way in which wellbeing is conceptualised influences what type of conclusions it is possible to draw (Dolan et al., 2006). There are several approaches to measuring wellbeing that can be broadly separated into two divisions: 1) Using objective indicators (observable facts such as health, social metrics or economic criteria) 2) Subjective measures (asking people to assess their own wellbeing according to defined criteria that may either be pre-defined or developed collaboratively with the survey participants) (Conceição and Bandura, 2008). Subjective measures can be operationalised in several different forms, ranging from multidimensional, deliberative and/or qualitative reflections on participant's own wellbeing to quantitative measures of self-assessed wellbeing (Conceição and Bandura, 2008). These two overarching divisions can be further subdivided into five approaches to defining wellbeing

(MacKerron, 2012), which are also often used in combination, such as in multi-dimensional approaches to wellbeing.

*Preference satisfaction:* wellbeing as determined by a person's ability to meet personal wants (Hausman and McPherson, 2009). This approach is rooted in the view that in situations where people are concerned with their own interests and are able to judge what will serve their interests, their preferences will be reliable indicators of what is good for them. Proponents of the preference satisfaction approach posit that welfare economics requires nothing more than an evidential connection between people's preferences and their welfare (Hausman and McPherson, 2009). However, there are some fundamental doubts associated with this approach. Individuals are often unable to predict the impact of future states (Wilson and Gilbert, 2003), an individual's behaviour does not always correspond to the individual's own preferences (Strack and Deutsch, 2004), and people are influenced by irrelevant factors of choice (Kahneman et al., 1999) and other behavioural phenomena (DellaVigna, 2009).

*Hedonic:* wellbeing as defined by dominant moods and feelings (Ryan and Deci, 2001). The hedonic approach measures the balance of pleasurable and unpleasurable feelings as experienced by the subject (Bruni, 2007) under the assumption that human beings aim to maximise the experience of pleasure and minimise the experience of pain (Henderson and Knight, 2012). The hedonic tradition can be traced back to the writings of Aristippus, Epicurus, Bentham, Locke, and Hobbes (Waterman et al., 2008). More recently, Kahneman et al. (1999) spearheaded the view that the terms wellbeing and hedonism are equivalent. Criticisms to a purely hedonic definition of wellbeing has been offered from the eudaimonic school of thought which argues that living a life with purpose is an important component of wellbeing (Crespo and Mesurado, 2015). There is evidence for both hedonic and eudaimonic dimensions being associated with positive affect, negative affect, and life satisfaction. However, the eudaimonic dimension was a more powerful predictor (McMahan and Estes, 2011).

*Eudaimonic:* wellbeing as a result of meeting one's full potential in various domains of life (Ryan and Deci, 2001). Eudaimonia has its roots in Aristotle's teachings – it is not a state of mind but an activity guided by reason, and partly relates to living virtuously rather than relating to a person's material or social circumstances (Crespo and Mesurado, 2015). It is associated with the positive psychology school of thought spearheaded by Seligman which has the aim 'to build human flourishing' (Seligman, 2011). Eudaimonic wellbeing is often contrasted with hedonic wellbeing, and there is evidence for a closer relationship between eudaimonia and measurable conditions related to wellbeing. The Midlife in the United States (MIDUS) national study found that while 48.5% of the sample scoored highly according to the criteria for hedonic wellbeing, only 18% were flourishing according to eudaimonic criteria (Keyes and Annas, 2009). Participants with high hedonic wellbeing but lower eudaimonic wellbeing had nearly double the rate of mental illness compared to individuals categorised as flourishing (Keyes and Annas, 2009).

*Evaluative:* individual self-evaluation of wellbeing (Frijters, 2020). Evaluative wellbeing is assessed by asking people for global assessments of their lives, most commonly by asking about their 'satisfaction with life as a whole' (MacKerron and Mourato, 2013). Orthodox, neo-classical economics relies on the preference satisfaction (PS) account of wellbeing but the new approach to wellbeing economics predominantly employs the evaluative way of assessing wellbeing (MacKerron, 2012). Preference satisfaction and evaluative accounts of wellbeing do share some core premises in that they "reject external criteria or judgements, privileging the individual as the only one qualified to assess his or her own wellbeing" (MacKerron, 2012). Evaluative wellbeing is usually presented as a separate category to hedonic and eudaimonic approaches to wellbeing, but I would argue that this separation does not correspond to how evaluative wellbeing is most commonly applied. Global evaluations of an individual's life can include hedonic and eudaimonic dimensions if those are important to the individual.

*Objective lists:* wellbeing as determined by defined material, social, and psychological needs (Forgeard et al., 2011). This approach is based on assumptions about fundamental human needs and rights (Dolan et al., 2011). The "lists" can be based on criteria that are believed to be common to all people, or they can be the result of an exploration of what wellbeing means to a specific community, and thereby be locally and culturally specific. Difficulties with such approaches include that they assume that criteria developed for a community can be adequately generalised to heterogenous individuals, and do not account for changes in wellbeing conceptions over time when used to compare wellbeing at different time points. Furthermore, there is also the challenge of weighting different aspect of wellbeing, leading many studies to weight them equally, though every indicator of wellbeing is unlikely to carry equal significance in the respondent's minds. One of the most well-known approaches is Sen's capability approach (MacKerron, 2012, Dolan and White, 2007).

Amartya Sen's work on inequality, development and wellbeing was influential in the shift from economic proxies of development as the dominant paradigm of development. Sen argues for a consideration of quality of life rather than just wealth or economic utility. He developed the basis for the comparative approach in general, and the capability approach as a concretisation of this approach (Baujard, 2013). The capability approach is able to encompass the ability to live well across several spheres of life. Quality of life is argued to be better captured with functionings, which Sen defines as "what the person succeeds in doing with the commodities and characteristics at his or her command. [...] It is an achievement of a person: what he or she manages to do or to be. [...]" (Sen, 1987). This approach intersects with the objective list accounts of wellbeing, as Sen argues that people need to have certain needs met, such as adequate food and freedom from persecution, in order to be able to fulfil their capabilities (Sen, 1992).The policy implication of Sen's capability approach is that the objective of public policy should be to provide the conditions that enable people to enhance the "capability set" (Dolan and Metcalfe, 2012).

Subsequent work has attempted to operationalise assessment of the conceptualisations of wellbeing developed by Sen, in light of early criticisms claiming that the Sen's approach lacked identification of specific capabilities that could be used for cross-cultural comparisons (Nussbaum, 1995). Nussbaum follows Aristotle, adopting a fundamental universalist view of human wellbeing that contends that there is a single notion of human flourishing. She considers certain basic human capabilities to be universal and proposes a concrete list of functionings (Nussbaum, 1987, Nussbaum and Sen, 1993). Human capabilities are framed as consistent, universal rights in order to facilitate adoption in public policy institutions (Robeyns, 2005). In contrast, Sen emphasises the relativity in notions of wellbeing, and argues for a public deliberative process rather than universal criteria (Baujard, 2013). This divergence is likely to arise from the respective goals of Sen and Nussbaum. Sen's capability approach was developed for work on poverty and development, while Nussbaum's approach is rooted in social justice and institutionalism (Clark, 2005).

The capability approach has influenced a number of multidimensional frameworks for studying wellbeing that aim to identify the different aspects of wellbeing (Alkire, 2002). The Voices of the Poor project carried out comparative fieldwork in a large number of nations (50 countries in its first phase and 23 countries in its second phase) to map how people view wellbeing as formulated by their own voices (Narayan et al., 2000, Narayan, 2000). The reports identified five components of wellbeing: material assets, health, social relations, security, and freedom of choice and action (Pender, 2002). Wider conceptual frameworks have been developed to combine several of these core components, for example the "Wellbeing in developing countries" approach (Gough and McGregor, 2007). The Well-being in Developing Countries Research Group (WeD) at the University of Bath was established to develop a conceptual and methodological framework for understanding construction of wellbeing (Gough and McGregor, 2007). This approach incorporates a complex combination of factors including human development, resources and agency, and individual and shared wellbeing (Agarwala et al., 2014). WeD gives "equal weight to the meaning that people give

to the goals they achieve, and the processes in which they engage, as to their resources and attainments" (Camfield, 2006). This produces comprehensive and locally relevant understandings of wellbeing and the factors that impacts wellbeing.

More fundamental criticism of Sen's approach comes from critics within the field of philosophy who criticise Sen's approach for logical inconsistencies in its underlying philosophical theory and for potentially resulting in paternalistic policies. Sumner (1996) argues that life satisfaction, unlike other measures of wellbeing, reliably captures the level of wellbeing of individuals. The subjectivist school of thought assumes that the individual's welfare is most accurately determined by the individual (the subject) in question, thereby avoiding paternalistic policies. Kaiser (2020) outlines the theoretical basis for this approach:  theories of welfare that are not subjectivist can come to the conclusion that *X* is good for subject *S*, despite *S* strongly denying that *X* is good for *S*. if it is conceivable for some subject *S* to deny that *X* is good for *S*, then *X* cannot constitute wellbeing for all *S*. Kaiser argues that most theoretical frameworks of wellbeing fail this test, including the capability approach as theorised by both Sen and Nussbaum. The capability approach posits that when the set of capabilities available to subject *S* is expanded, then the wellbeing of subject S is improved. Under the subjectivism, any particular extension of the capability set benefits does not necessarily relate to the wellbeing of *S*. Kaiser (2020) argues that variables identified by non-subjectivist approaches only track wellbeing indirectly. A significant weakness of Kaiser's approach is the role of adaptation in self-assessments of wellbeing: people might become accustomed to living under difficult conditions, which would be revealed as unacceptable by, for example, Nussbaum's approach. Therefore, cross-cultural comparisons of self-assessed life satisfaction scores cannot be readily compared. However, for internal comparisons of wellbeing and for studying the explanatory factors that influence wellbeing within relevant reference groups, self-assessments of wellbeing have been shown to be robust (Laffan, 2017). There is a large body of evidence for the relationship between self-assessed life satisfaction and reliable indicators of wellbeing from observational, experimental and

physiological studies (the evidence is further discussed below). On the other hand, single measures such as life satisfaction do not allow for disaggregation of the components of wellbeing, and does not elucidate the relative relationships between the different components, which limits its use for nuanced policy-making. The optimal choice of framework will depend on the aims of the research. The topic of this thesis is wellbeing in the form of self-reported life satisfaction, and that will be the focus for the rest of this thesis, in line with other economic PhD theses on this topic.

### 1.6.5. Choice of framework

The decision to use quantitative measures of life satisfaction (LS) as the metric for my analysis of wellbeing was made due to 1. The limitations of multidimensional frameworks, such as Sen's approach, as discussed above. 2. The strengths of the LS approach its ability to encompass heterogenous conceptions of wellbeing across individuals and time (discussed in the following paragraphs). 3. The robust observational, experimental and physiological evidence underpinning the quantitative LS approach (discussed in section 6.2.2.). 4. Only quantitative LS can be used for economic valuation (discussed in section 1.6.6).

Life satisfaction can be conceptualised as being composed of a balance of affect (positive and negative emotions) and a cognitive assessment of how well your life compares to your aspirations (Treasury, 2011). LS data, being used as proxy utility data, has enabled the testing of many of the assumptions of conventional economical models that were not previously testable (Chen et al., 2019).

LS is measured through asking respondents to rate their satisfaction with their own life on an ordinal scale and employing multiple regression models to explore the relationship between LS and explanatory variables (Ballas and Tranmer, 2012). The LS approach asserts the centrality of the individual and is based on the belief that the individual rather than the researchers is the best judge of own wellbeing, thereby reducing disciplinary and cultural biases (Agarwala et al., 2014). Imposing

external definitions of wellbeing entails ethical implications and can undermine the legitimacy of any conservation intervention in the eyes of the communities involved (Milner-Gulland et al., 2014). The LS approach recognises that the determinants of wellbeing differ across not only cultures but also through time. Socio-cultural contexts evolve continuously and therefore so do people's concept of wellbeing. The LS approach does not rely on fixed indicators of wellbeing and therefore allows for change in what is considered components of wellbeing, as well as changes in the relative importance of these components (Agarwala et al., 2014).

### 1.6.6. LS and economic valuation

When a metric for wealth or income is included among the explanatory variables in the LS regression analysis, this variable can be used to derive the economic value of another explanatory variable by calculating the marginal rate of substitution between the monetary variable and the variable that is to be valued. This marginal rate of substitution represents the level at which wealth and the variable of interest can be traded-off and leave people on average equally happy. For example, in a study of trade-off between income and air quality, a 1 µg/m3 reduction in PM10 was found to increase LS to an equivalent degree as earning US$459 more per year (Levinson, 2012). This is usually termed the willingness-to-pay (WTP) for the variable in question.

LS can be written as

$$S_{it} = \alpha \log(y_{it}) + \beta h_{it} + \sum_{k} \gamma_k \, z_k + \varepsilon$$

where $y_{it}$ is income and hit is the variable that we want to value, for example pollution level. Then, the estimated α and β can be used to calculate the change in wealth or income that would be equivalent to a change in pollution levels (Ferrer-i-Carbonell, 2013).

As discussed in section 1.5, economic valuation techniques can be divided into revealed preference techniques and stated preference techniques. Both choice experiments and the life satisfaction method are stated preference techniques, but choice experiments suffer from some important sources of bias that do not apply to the life satisfaction approach: warm glow (where respondents overstate WTP for the emotional reward of contributing to a good cause without real cost) (Nunes and Schokkaert, 2003) and scope effects (insensitivity to the size of the good being valued) (Borzykowski et al., 2018). LS methods for economic valuation are not subject to these biases as the respondents do not directly express WTP, but it is instead inferred statistically from LS regressions. The central assumption of economic valuation methods is that LS is an accurate proxy for underlying utility and that the utility function and its indifference curves can be observed through LS ratings (Treasury, 2011). In the literature that utilises wellbeing for the purposes of economic valuation, LS is considered the metric of wellbeing that corresponds most closely to the economic notion of utility and is the most widely used metric (Treasury, 2011).

### 1.6.7. Past work on wildlife and life satisfaction

There have been several studies on the impact of protected areas on the wellbeing of the communities that live alongside them (Pullin et al., 2013, Ban et al., 2019), but none that use quantitative analysis of subjective wellbeing to assess the influence of wildlife on these communities. Chapter 5 which uses the LS approach to produce an economic value estimate of the presence of lions from the perspective of the local communities around Hwange National Park in Zimbabwe provides a novel application of this method as well as policy-relevant information for mitigating the externalities arising from Hwange National Park.

## 1.7. Study site

The study area encompassed 20 agro-pastoral villages in the Mabale area of Hwange Communal Land (Figure 1), Dingani chieftainship, located outside the northern boundaries of Hwange National Park and Sikumi Forest Area in Zimbabwe (Loveridge et al., 2017a). The density of homesteads in the Mabale area is 6.2/km2. The majority ethnic groups are Ndebele, Nambya and Tonga peoples. Lions that move into inhabited areas outside the park pose a threat to livestock and human safety, and are vulnerable to persecution (maiming or killing) by people (Loveridge et al., 2017b). These killings may be carried out through legal procedures by applying for Problem Animal Control (PAC), or by illegally killing lions with snares (Loveridge and Hunt, 2016, Karidozo et al., 2016). Since 2007, the Trans-Kalahari Predator Programme (TKPP) has been implementing activities to reduce the impacts of lions on the livelihoods and wellbeing of local people , currently consisting of two main interlinked activities. The community guardian programme employs people from the local communities to advise the villages on livestock protection measures and to undertake direct mitigation measures. These guardians also assist with the deterrence of lions found close to human habitations – such lions are chased back into the national park using loud sounds (Petracca et al., 2019). The project also runs a programme that provides mobile bomas to communities. The mobile bomas are enclosures for protecting livestock, particularly during the night. They are highly effective at excluding predators, unlike the traditional wooden corrals (Loveridge and Hunt, 2016). Some villages have community guardians only, some have both guardians and mobile bomas and some have neither. There are no villages that have only mobile bomas, as these are always placed in areas where community guardians operate.

### 1.7.1. Institutional context

Wildlife is managed jointly by the Zimbabwean Parks and Wildlife Management Authority (ZPWMA) and the Rural District Councils (RDCs) (Sibanda et al., 2020). Communal Areas Management

Programme For Indigenous Resources (CAMPFIRE) operates in the area, and aims to distribute revenue from tourism, trophy hunting and land-leasing fees (Frost and Bond, 2008). The aim is for the RDCs to distribute 55% of the CAMPFIRE revenue to community-development projects, but these benefits are rarely experienced by local communities and there is widespread dissatisfaction with CAMPFIRE in the area (Sibanda et al., 2020).

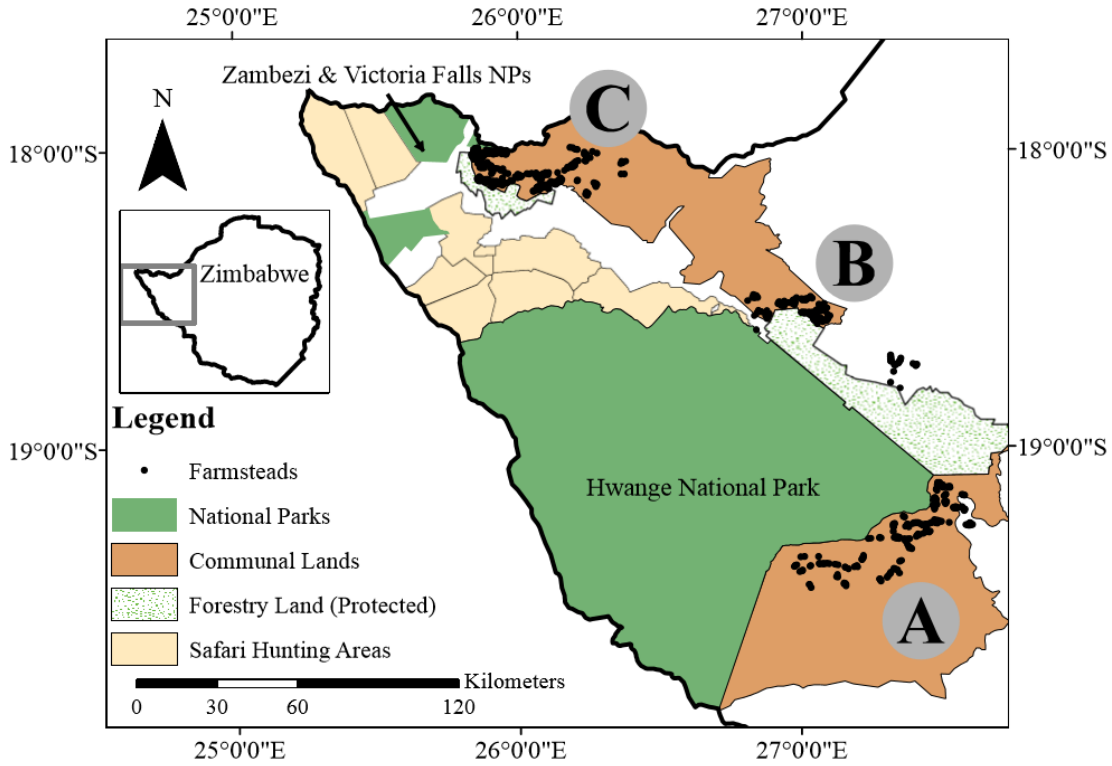



Fig 1. Hwange National Park is surrounded by three community areas: A) Tsholotsho B) Mabale C) Victoria Falls. This work was carried out in Mabale (A). Image source: Loveridge et al. 2017

## 1.8. Positionality statement

For the purposes of identifying biases in the application of scientific methods within research, reflection and self-ethnography is increasingly being called for (Jäger et al., 2013, Mosse, 2011). The

ontology and epistemology of the researcher affects how they design their research (Moon et al., 2019).

The research contained in this thesis was carried out within the organisational framework of the Wildlife Conservation Research Unit (WildCRU) and the Trans-Kalahari Predator Project (TKPP). WildCRU is part of the Department of Zoology at the University of Oxford, with high levels of input from collaborators within the field of Economics (London School of Economics and University of Stirling). The background of the supervisors and collaborators thereby fall into either conservation ecology or economics, primarily using quantitative methods. My academic background is mixed, with previous degrees within biological sciences and social sciences. I have used both quantitative and qualitative research methods for my previous research but with epistemological emphasis on empirical methods throughout.

The cultural background of the authors is a mix of Western European and Zimbabwean backgrounds. My personal background is from rural Norway on the border of a national park. Carnivores have largely been extirpated from the area and attitudes to carnivores in the area are strongly negative, but my personal value-orientation lead me to hold pro-carnivore views through my upbringing.

# CHAPTER 2. Exploratory qualitative interviews

## 2.1. INTRODUCTION

Local cultural context exerts strong influence on the outcome of community-based conservation interventions, and a systematic review on conservation interventions found that conservation practitioners need a better understanding of, and adjustments to, the community (Waylen et al., 2010). Prior to designing surveys, experiments, or other forms of data collection, researchers should familiarise themselves with the local context. There are many different disciplinary approaches to do this, from the immersion used in ethnography (Jones and Smith, 2017) to structured qualitative interviews (May, 2011). The motivation for employing these techniques as alternatives to conventional empirical-analytic research is to add a missing subjective component (Packer, 2017). Empirical-analytical research can elucidate objective events, but not how they are experienced and the meaning that people construct (Packer, 2017). Prior to designing the survey and choice experiment, I used semi-structured, qualitative interviews to familiarise myself with how local people live their lives and their viewpoints on lions and lion conservation. This is considered best practice in order to ensure that the researcher has the necessary understanding of the local context to be able to produce sensible surveys and experiments, and to help the researcher interpret the

results of surveys and experiments. Unfortunately, it is very common for researchers to skip this exploratory interview step altogether when developing survey instruments. The exploratory semi-structured qualitative interviews did not constitute formal data collection as they, per definition, should be carried out prior to data collection.

### 2.1.1. Semi-structured qualitative interviews

Compared to both quantitative data and highly structured interviews, the strength of qualitative semi-structured interviews lies in "providing background information and context, generating ideas, and providing in-depth information on each participant's views, perspectives and motivations" (Newing, 2010, p.98). Other possibilities exists, such as focus groups, unstructured interviews and life histories, but semi-structured interviews is referred to as the workhorse of qualitative research (Packer, 2017). Semi-structured interviews are defined by the questioning approach: they are based on a pre-prepared interview guide, but interviewees are allowed a great deal of freedom in how they answer the questions, and both the interviewer and interviewees can introduce new topics for discussion. The aim of such an interview is to enable the interviewee to speak in their own words in order to obtain a first-person account (Longhurst, 2003). Semi-structured interviews can be applied for a wide range of purposes, from discovering information from one specific person with particular knowledge of a topic, or to explore the views of a sample of people from a population of interest (Newing, 2010).

### 2.1.2. The ontology and epistemology of semi-structured qualitative interviews

The process of carrying out qualitative interviews is embedded in ontological and epistemological commitments (Packer, 2017). The established paradigm of survey research is to strive towards

developing interviews to be neutral and reliable scientific instruments, analogous to measurement instruments used for physical objects (Packer, 2017). This approach operates under the assumption that to discover information about people's attitudes and beliefs, everyone must be presented with the same standardised stimuli (Gorden, 1975). Responses to structured questions have been shown to be influenced by the phrasing of the question, by grammar, the order of the questions, contextual factors and by attributes of the interviewers themselves. In reaction to this, efforts have been made to impose even more stringent external constraints on how questions are phrased and presented, as well as the categories of answers that are acceptable (Packer, 2017). Suchman and Jordan (1990) argue that such efforts to produce reliable interview instruments have the unintended consequence of undermining their ability to provide valid information as many of the interactional resources of ordinary conservation are prohibited. The interviewer is not allowed to respond to unfolding events or contextual circumstances which leads to inappropriate questions being asked, and potentially enlightening questions being missed. Such restricted interviews encounter problems whenever the interviewer and the interviewee do not share assumptions about the world (Suchman and Jordan, 1990). Suchman and Jordan (1990) further argue that in the absence of shared assumptions and contextual understanding, both parties in the interview must make their best guesses to imagine the context and assuming what the words mean to the other party, which leads to the collection of flawed data which results in questionable analyses.

In contrast, semi-structured interviews recognise the interview as a form of discourse between the speakers, which avoids these problems by enabling the interviewer to make the use of ordinary conversational skills (Mishler, 1991). The interview is a joint production (Packer, 2017).

### 2.1.3. The role of subjectivity in qualitative interviews

In-depth qualitative interviews are rooted in "meaning-making" – the subjective process of conceptualizing the world around us (Bruner, 1986, p.68). If accepting that qualitative research is the

study of meaning, this requires the researcher to be devoted to accessing the subjective interpretations that people attach to their objective circumstances (Dowling, 2005). Consequently, qualitative research is the objective study of subjectivity (Bogdan and Biklen, 1997), where the research is a process of cooperation based on dialogue (Packer, 2017).

In the qualitative interview process, it is not only the subjectivity of the interviewee that contributes to the findings. If accepting that experience and knowledge are subjective, that leads to the conclusion that the researchers has subjectivity too, and raises questions about whether they can claim that the results are objective (Packer, 2017). Packer (2017) argues that the aim of a subjective agent creating objective knowledge is a paradox, which the empirical-analytic sciences attempt to solve by building on measurement and logic, which is seemingly free of interpretation. This is not possible with qualitative research such as the semi-structured interviews used in this chapter. Qualitative researchers nonetheless need to find some way to solve this paradox, and I opted to combine the two approaches presented by (Packer, 2017): the researcher can attempt to overcome their subjective influence as far as possible by following special rules or procedures, but can also accept the subjectivity of the researchers as a collaborator in the interview and interpret the results accordingly. The production of qualitative research involves a complex relationship between the interviewer, interviewee, transcriber, the researchers carrying out the analysis, the reviewers and editors involved in the publishing process and the interpretation of the readers (Packer, 2017). The interviews discussed in this chapter were exploratory, to inform data collection rather than to serve as qualitative data for analysis, so only the first part of this chain applies. The interviews informed the selection of topics to be piloted as part of the first draft of the survey, choice experiments and wellbeing regression. The piloting provides a process where participants remove irrelevant or misleading questions and add any important topics that they consider that the questionnaire/experiment is still missing. This provides an additional step after the qualitative interviews where the participants evaluate the interpretation of the interviewers, which enhances

the influence of the participant's subjectivity in the design of the questionnaire/experiments relative to the contribution of the interviewers' subjectivity.

## 2.2. METHODS

### 2.2.1. Selection of interviewers and participants

The interviews were carried out on the first field visit, 6 months before beginning data collection (Chapters 3 – 5). All the interviews were carried out by the author of this thesis and Lovemore Sibanda, who works as the community liaison at the TKPP. Sibanda acted as interpreter, as he is fluent in Ndebele, Tonga and Nambya languages, and provided cultural competence. The interview locations were selected within the Mabale area, strategically selected to cover a range of conflict levels. The metric for conflict level was the recorded number of livestock losses or injuries recorded by the TKPP in each village area from 2008 – 2019 (no data was recorded by TKPP prior to 2008). The sampling process was strategic sampling for range: the researcher identifies sub-categories of the group under study and ensures that individuals belonging to every category is interviewed (Small, 2009). I therefore chose participants to include individuals across the spectrum of age, wealth, gender, livelihood, ethnicity and geographic location. An alternative approach that is commonly used would have been snow-ball sampling, which is known to increase the number of respondents participating (Small, 2009), but I decided on strategic sampling of range, as the priority was to cover the full range of different viewpoints that exist in the population, rather than achieving a high number of individuals participating (Cross, 2005). The aim was not to achieve a sample that proportionally reflects the wider population, but instead to capture information-rich individuals (Watts and Stenner, 2012).

Prior, informed consent was obtained from all participants. The interaction was initiated by explaining to the potential participant who we were, our institutional affiliations, the purpose of the

interview, what participation in the interview would entail, and what the information would be used for.

### 2.2.2. Interview guide

We carried out the interviews according to a pre-prepared interview guide (Table 1). The questions in the interview guide were developed through a review of literature (De Vaus and de Vaus, 2013) on human-wildlife conflict, and from conversations with knowledgeable individuals with formal and informal expertise: academics, conservation practitioners, field teams, employees at the TKPP field station and community guardians. The questions were chosen in order to achieve improved understanding of the views of the local communities towards lions, the presence of wildlife, the national park, conservation efforts, as well as their livelihoods and the other challenges people face besides wildlife. In semi-structured interviews, the emphasis is on the interaction between the interviewer and the interviewee, and the aim is to let the interviewee to lead the course of conversation as much as possible, so the questions in the interview guide only served as starting points for conversation in order to focus the conversation on the themes of interest (Newing, 2010, Longhurst, 2003). However, we had to be conscious of the possibility that our pre-determined themes were missing important topics, or included topics that were not salient in the minds and lives of the communities. Therefore, the interview guide was developed through an iterative improvement process, where additional questions and topics that respondents brought up were added to the list of questions for subsequent interviews.

Table 1. Interview guide. Questions 1 – 24 served as starting points for each topic of conversation, which was then developed conversationally by the interviewers.

| **Question** |
|---|
| 1. How long have you lived in the Hwange area? |
| 2. How do you feel about living in close proximity to lions? |
| 3. How does the presence of lions influence your life? |
| 4. How do you feel about the lions themselves? |
| 5. Do lions have any spiritual significance in your community? |
| 6. Are you familiar with wildlife compensation schemes? |
| 7. How would you feel about a wildlife compensation policy that compensates people living in your area for the effects of lion presence? |
| 8. Are you familiar with any conservation projects operating in the area? |
| 9. Are you familiar with the Trans-Kalahari Predator Project? |
| 10. What are your views on the work of the conservation projects operating in this area? |
| 11. Has your village participated in the community guardian programme or the mobile bomas? |
| 12. What is your opinion on the community guardian programme? |
| 13. What is your opinion on the mobile bomas? |
| 14. How do you feel about the presence of Hwange National Park? |
| 15. Have you had any negative or positive experiences relating to park management? |
| 16. How do you feel about living so close to the wildlife in the national park? |
| 17. Have you experienced any difficulties associated with wildlife other than lions? |
| 18. Are there any further aspect of living alongside lions and wildlife that you think we should be aware of? |
| 19. How do you make your living? |
| 20. Do you have livestock? If so, how do you raise them? |
| 21. What is most important for your wellbeing? |
| 22. What are the biggest challenges you face in your life? |
| 23. What are your aspirations for your life? |
| 24. Is there anything more you think that it is important that we are aware of? |

### 2.2.3. Interview process

The interview guide provided standardised starting points for conversation, but the in the semi-structured approach, the goal is for the interviewer to direct the conversation as little as possible in order for the conversation to reflect the views, attitudes and knowledge of the interviewee as closely as possible (Newing, 2010). For every question on the interview guide, we let the interviewee speak in response to the question, and then presented follow-up questions to the statements made by the interviewee. The interviewee's response to our follow-up question became the source of further follow-up questions. We explored each such topic of conversation until it came to a natural end, or became circular (returning to topics previously discussed). Then we proceeded to the next question on our interview guide. As a result of this semi-structured process, each interview developed differently and many covered different topics, as the interviewee had a key role in determining the direction of conversation (Newing, 2010, Longhurst, 2003). As the process of repeated refinement of the interview guide progressed, interviews became slightly less diverse as the interview guide to an increasing degree covered the topics that were important to the people in the Mabale area (though there were of course still substantial individual differences).

We did not set out with a pre-decided number of interviews in mind, the end of the exploratory interview phase as indicated by the evolution of the content of the interviews. This process followed Yin (2011)'s approach of sequential interviewing, where each case provides in increasingly accurate understanding of the topics of interest. The goal is saturation (Small, 2009). The first interview yields a set of findings and a set of questions that informs the next interview, until the last interview provides very little new information.

## 2.3. RESULTS

The result that I were aiming for was the transformative effect of the conversations within the interviews on my understanding of the local context. I also wanted to pick up on any important topics that we were not aware of after reviewing the literature and talking to knowledgeable individuals within conservation in the area, particularly the people working for TKPP. We followed the procedure described by Bogdan and Biklen (1992) and wrote memos on the interviews during the interview process, which summarises new items of learning. These memos formed the basis for expanding the range of topics to be included in the first draft of the survey and choice experiments used for data collection in this thesis, and as aid for interpreting model results in the data chapters. Most of what emerged through the interviews we were already aware of through literature and conversations with TKPP staff. Topics that had not already been identified through our literature search and that emerged as important in the local context are summarised below.

### 2.3.1. Bequest value of lions

One of the most important areas we wished to cover in our interviews were an exploration of the value that people attach to lions, if any at all. Though people's attitude to the presence of lions were largely negative, there was also some value expressed in association with the presence of lions. The benefits from tourism were expected based on our prior knowledge, but some interviewees also expressed bequest value attached to lions. Bequest value is defined as the desire to preserve a resource for the sake of future generations (Walsh et al., 1984). Interviewees expressed that they wanted lions to be preserved for their children to see and know.

### 2.3.2. Existence value of lions

Another type of value attached to lions also emerged from the interviews. Some interviewees expressed existence value attached to lions. Existence value refers to the satisfaction derived from the knowledge that something (such as a wildlife or plant species, a cultural practice, a landscape or cultural site) exists (Madariaga and McConnell, 1987). Some interviewees expressed that they would like to live entirely separated from lions, but they wanted the species to exist somewhere. Lions disappearing entirely was perceived as a loss for some interviewees, despite having no desire to view lions, engage with tourism, compensation schemes or any other ways of benefitting from their existence.

### 2.3.3. Traditional religion

It is well established in the literature on human-carnivore conflict and co-existence that religion and traditional beliefs can be influential on people's attitudes towards large carnivores. We suspected that was the case in the communities around Hwange National park, but we were not sure. The exploratory interviews revealed that lions does indeed hold a place in both traditional religious practices and in folkloric beliefs. There is a lion shrine within the national park, at a secret location, where village chiefs perform ceremonies. There is also a folkloric tradition stating that hearing the roar of lions herald good harvests. The lion therefore has a place within the spiritual beliefs of some members of the communities. However, establishing how closely linked the spiritual aspects of lions are to the physical presence of lions in the mind of the community members would require in-depth ethnographic investigation.

### 2.3.4. Negative preference to compensation payments

The most surprising finding in the exploratory interviews was that some interviewees expressed negative preferences towards monetary payments. This was an important discovery because many methods of economic valuation assume positive preferences for money, so the choice of methods should be adapted accordingly. When delving into the reasons behind negative preference towards monetary payments, the reasons given fell within three categories. The first was a worry about jealousy from neighbours or surrounding communities. The second related to safety concerns; some interviewees worried that cash wealth would make them targets for crime. The final category related to religion; some interviewees stated that wealth was incompatible with Christian virtues and cited the bible saying that a rich man cannot enter heaven. This provided important insights that shaped my choice of economic valuation instruments and the interpretation of the model results from the economic valuation models.

## 2.4. CONCLUSION

Semi-structured qualitative interviews proved highly suitable for exploring the local context and the viewpoints of people living in the communities in the Mabale area of Hwange national park. The semi-structured approach allowed the interviewers to follow the lead of the interviewee in guiding the conversation to reflect the concerns and priorities of the interviewee rather than the preconceptions of the interviewers, within the framework of the list of starting topics in the interview guide. The interviews revealed some important insights that helped shape the development of the surveys and experiments that were later used for data collection. The interviews revealed a diverse set of values attached to lions, which included bequest value and existence value. They also revealed the role of lions in traditional religion and folklore, and that not all community members held positive preferences towards monetary payments. This ensured the selection of

appropriate survey questions and economic valuation instruments, and aided in the interpretation of the model results.

# CHAPTER 3. Fear, ecocentricity and religion – intangible factors matter for human-lion coexistence

## 3.1. ABSTRACT

Conflict with humans is one of the major threats facing the world's remaining large carnivore populations, and understanding human attitudes is key to improving coexistence. Here, we use a socio-ecological model to understand local attitudes towards coexisting with lions. We investigate the importance of a range of tangible and intangible factors on attitudes, including the costs and benefits of wildlife presence, emotion, culture, religion, vulnerability, risk perception, notions of responsibility and personal value orientations. This is for the purpose of effectively tailoring

conservation efforts, but also for ethical policymaking. We found that intangible factors (such as fear and ecocentric values) are as important, if not more important, than tangible factors (such as livestock losses) for understanding attitudes. This was based on the effect sizes of these variables. The degree to which participants' fear of lions interfered with their daily activities was the most influential variable. The degree to which benefits accrue to households from the nearby protected area was also highly influential, along with the numbers of livestock lost, number of dependants, ecocentric value-orientation, and participation in conflict mitigation programmes. Contrary to what is often assumed, metrics of livestock loss did not dominate attitudes to coexistence with lions. Furthermore, we show that socio-economic variables may appear important when studied in isolation, but their effect may disappear when controlling for variables related to beliefs, perceptions and past experiences. This raises questions about the widespread reliance on socio-economic variables in the field of human-wildlife conflict and coexistence. To facilitate coexistence with large carnivores, we recommend measures that reduce fear (both through education and through protective measures that reduce the need to be fearful), reduction of livestock losses and ensuring local communities experience tangible and relevant benefits from conservation. Ecocentric values also emerged as influential, highlighting the need to develop conservation initiatives which are tailored with local values.

## 3.2. INTRODUCTION

The neighbourly relations between wildlife and the communities that live alongside them are often strained. Understanding the determinants of coexistence requires exploration of intangible factors, which the field of human-wildlife conflict and coexistence is calling for(e.g. Barua et al. (2013)).. Most large carnivores have suffered significant population declines and range contractions (Ripple et al., 2014), and lions in particular have experienced a 92% reduction in their historic range (Bauer et al., 2016). Human-lion conflict is among the top threats to lion populations (Funston et al., 2016).

Across the wide range of human-wildlife conflicts, humans are the only constants and effective conservation depends on understanding the thoughts and actions of the people involved (St John et al., 2013).

The amount of damage that carnivores inflict often influences the extent to which people tolerate them (Mitchell et al., 2019, Dickman, 2009). However, direct damage is not the only determinant of hostility, and is not necessarily even the main driver, so reducing it may not reduce hostility (Dickman, 2010). Pooley et al. (2017) recognise the same phenomenon and conclude that there is too much focus on negative impacts, oversimplified assumptions that levels of conflict relate proportionately to levels of damage, and technical fixes that fail due to a failure to engage local stakeholders or address hidden costs.

Rational choice theory has been found to poorly explain human-carnivore interactions (Gebresenbet et al., 2018a). To mitigate human-wildlife conflict, we need to understand the attitudes of the people involved and the complex web of socio-economic factors, past experiences, culture, beliefs and values that influence those attitudes (Dietsch et al., 2019). This has led to calls for greater focus on the intangible aspects of conflict and coexistence, e.g. Kansky and Knight (2014). Attitudes are often a strong predictor of intention to behave in a certain way (Fulton et al., 1996) and can therefore provide insights on people's willingness to coexist with wildlife. However, there is far from an automatic link between attitudes and actions (Dickman and Hazzah, 2016). Factors outside the individual (e.g. social context) have a strong influence on people's behaviour beyond the effect of internal factors that drive attitudes (Heberlein, 2012). However, in this study we were not just interested in specific behaviours. This work has the dual aim of casting light on the importance of intangible factors, thereby informing effective conservation efforts, and understanding the viewpoints of the communities for their own sake. The second aim is of equal importance. This relates to concepts of environmental justice (Lecuyer et al., 2019). The recognition of stakeholders'

identity and viewpoints has been shown to be an integral part of environmental justice for stakeholders in carnivore management (Jacobsen and Linnell, 2016).

In this paper, we will use attitude as defined by Kansky et al. 2014, based on the work of (Fishbein and Ajzen, 2011): "Attitudes can be defined as a disposition or tendency to respond with some degree of favorableness, or not, to a psychological object, the psychological object being any discernible aspect of an individual's world including an object, a person, an issue, or a behaviour" (Kansky et al., 2014).

We investigate how a wide range of factors relate to the willingness of stakeholders to coexist with lions in Zimbabwe, using a structured questionnaire. These include socio-economic and demographic attributes as well as key indicators of the impact of lions (e.g. livestock loss). We also explore how emotions (such as fear), culture, religion, vulnerability, risk perception, notions of responsibility and ecocentric value orientations affect attitude. The aspect of ecocentric values evaluated in this study was the belief that components of nature (specifically lions) have an intrinsic right to exist (Washington et al., 2017). Fear is a complex emotion and people are likely to have different thresholds for how they delineate such emotions. We therefore employed a situationally specific indicator of fear, asking survey participants to what extent fear of lions interfere with their daily lives. We incorporate ecological data on predation to create a socio-ecological model, and we incorporate evaluation of the effectiveness of conflict mitigation activities in the area. Our hypotheses were A) Intangible factors are among the most influential variables associated with attitude to coexistence with lions. B) Variables that are indicators of higher risk and vulnerability to livestock depredation are associated with more negative attitudes to coexistence with lions. C) Predictions of attitude using models that include variables pertaining to beliefs and past experiences will substantially outperform models based on socio-economic variables alone. D) We test the novel hypothesis that lack of ownership of wealth leads to discounting of livestock damages.

## 3.3. METHODS

### 3.3.1. Study site:

The study area encompassed 20 agro-pastoral villages in the Mabale area located just outside of Hwange National Park in Zimbabwe. Lions that move into inhabited areas outside the park pose a threat to livestock and are vulnerable to persecution by humans which causes mortality and injury to lions. Since 2007, the Trans-Kalahari Predator Programme (TKPP) has been implementing activities to reduce the impacts of lions on the livelihoods and wellbeing of local people, currently consisting of two main activities. The community guardian programme employs people from the local communities to advise villages on livestock protection measures and assist with chasing lions found close to human habitation back into the protected area (Petracca et al., 2019). The project also runs a programme that provides mobile bomas to communities. These "bomas" are enclosures for protecting livestock, particularly during the night. They consist of PVC canvas sheets that are used to construct a fence around the cattle. Some villages only have community guardians, some have both guardians and mobile bomas and some have neither (Loveridge and Hunt, 2016).

### 3.3.2. Survey design and data collection:

The questionnaire was designed based on exploratory qualitative interviews and academic literature (chapter 2) translated into Ndebele, Nambya and Tonga languages, with content-validation tests for every question. The survey went through three rounds of piloting. The survey was carried out by a team of six native speakers employed solely to carry out this survey and thoroughly trained in interview technique and data collection over a period of 2 weeks preceding data collection (and several had previous research experience). All interviewers came from the greater Hwange area in order to encourage trust and ensure culturally appropriate behaviour. The data collection was carried out April- June 2017

20 villages were randomly selected from the Mabale area within 30km of the border of the national park. The 30km cut-off was chosen because that corresponds with the appropriate scale of lion ranges in this area (though dispersing lions may move further, dispersal events are irregular). We interviewed every person in every household in the target villages whenever possible, with the exception of households that had been visited for the exploratory qualitative interviews. Only people above the age of 18 and who were not under the influence of alcohol were interviewed. 1482 people were interviewed living in 593 different households. Prior informed consent was obtained from each individual according to the approved guidelines of Oxford University's Research Ethics committee (Ref. no. R49682/RE001). Answers were recorded anonymously using the software Qualtrics (Qualtrics, 2017). All data for this thesis was collected in the same survey.

3.3.3. Variable choice:

The response variable was a Likert-type item ranging from "very negative" to "very positive" on a five-point scale in response to the question "How do you feel about having lions in your area?". "Very negative" was coded 1 and "very positive" was coded 5.

The independent variables were chosen by reviewing existing literature and through exploratory qualitative interviews with villagers from the relevant communities. *A priori* hypotheses for every variable can be found in Table S1 (Supplementary materials). Ecological data on lion depredation events collected by the Trans-Kalahari Predator Programme were incorporated along with the social survey data. The depredation data consist of the number of livestock killed by lions confirmed by TKPP field staff within the area of each village through the entire period that such data has been collected by the project (2008 – 2019), and were incorporated in the analysis as a village-level variable (referred to as the conflict level of the village).

Due to the attention afforded to livestock losses in the literature, we included variables relating to several aspects of livestock loss, risks and vulnerability. We included both losses at the level of the

individual and the conflict level of the village (the average annual number of livestock that were killed by lions based on data collected by the TKPP). To determine which aspects of individual vulnerability and risk are important, we included information on whether respondents owned any livestock, how many livestock they owned (in case attitude showed a trend with livestock ownership rather than a binary effect), how dependent they were on livestock for income (indicated by the proportion of their total wealth that consists of livestock) and total wealth (wealthier people are hypothesised to be better able to absorb losses of livestock). The amount of wealth an individual possessed in the form of livestock was calculated based on the market value of the livestock the household owned, divided by the number of individuals in the household to derive a per-person figure. The total wealth measures the total annual value of the person's crop production, livestock, formal employment and informal work. All types of livestock were included, except in the variable describing the number of livestock owned, where poultry were excluded. The market value of livestock was obtained from the TKPP Community Survey (2010). Crop production was estimated by asking about the household's production at the last harvest.

Table 1. Variable types, question wording, answer scales and model composition (CM= Comprehensive model, SEM = Socio-economic model, Past experiences with conservation model (PEM), BPM = Beliefs and perceptions model, MM = Management model).

| Variable | Answer scale | CM | SEM | PEM | BPM | MM |
|---|---|---|---|---|---|---|
| Response variable: Attitude to coexistence with lions: "How do you feel about having lions in your area?" | Ordinal categorical: *Very negative (46%), Quite negative (35%), Indifferent (11%), Quite positive (7%), Very positive (1%)* | ✓ | ✓ | ✓ | ✓ | ✓ |
| Random variable: Name of village | Nominal categorical | ✓ | ✓ | ✓ | ✓ | ✓ |
| Gender | Nominal categorical: *Male (44%), Female (56%)* | ✓ | ✓ | | | ✓ |
| Ethnicity: "What is your mother tongue?" | Nominal categorical: *Ndbele, Nambya, Tonga, Other* | ✓ | ✓ | | | ✓ |
| Education: "What is your level of education?" | Ordinal categorical: *None (5%), Primary (33%), Secondary (57%), Tertiary (5%)* | ✓ | ✓ | | | |
| Age: "How old are you?" | Continuous numeric (range = 18-94) | ✓ | ✓ | | | ✓ |
| Number of dependants: "How many children or elderly people who are past working age, or sick/disabled people who cannot work do you provide for?" | Continuous numeric (range = 0-13) | ✓ | ✓ | | | |
| Physical condition: "Considering the last 12 months, how are you feeling physically?" | Ordinal categorical: *0 (Very unwell, 6%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Very well, 37%)* | ✓ | ✓ | | | |
| Employment in wildlife work: "Do you or anyone in your household work for Hwange National Park or The Hwange Lion Project?" | Nominal categorical: *Yes (21%), No (79%)* | ✓ | ✓ | | | |
| Total wealth (US$) | Continuous numeric: *Sum of individual's wealth from all sources; livestock, crops, employment and informal work* | ✓ | ✓ | | | |

| | | | | | |
|---|---|---|---|---|---|
| | (range = 10-15316<br>) | | | | |
| Whether own livestock: “Do you or anyone in your household own livestock (cattle, goats, poultry and so on)?” | Nominal categorical: *Yes (90%), No (10%)* | ✓ | ✓ | | |
| Number of livestock owned, excluding poultry: “What livestock does your household own? And how many?” | Continuous numeric (range = 0-29) | ✓ | ✓ | | |
| Proportion of non-animal wealth: Proportion of wealth derived from non-animal sources | Continuous numeric (range = 0.02-1) | ✓ | ✓ | | |
| Satisfaction with material circumstances: “How satisfied are you with your current standard of living (material circumstances)?” | Ordinal categorical: *0 (Extremely dissatisfied, 12%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Extremely satisfied, 12%)* | ✓ | ✓ | | |
| Ownership of wealth: “In your household, who makes most decisions on how money is spent?” | Nominal categorical: *Me (28%), Someone else (32%), Equally shared with someone else (40%)* | ✓ | ✓ | | |
| Number of livestock lost to lions: “How many livestock have you lost to lions in the last 3 years?” | Continuous numeric (range = 0-58) | ✓ | ✓ | ✓ | ✓ |
| Frequency of seeing lions: “Have you ever seen a lion before, if so how many times?” | Ordinal categorical: *Never (51%), One time (18%), A couple of times (13%), Many times (18%)* | ✓ | | ✓ | |
| Personally know someone attacked by lion: “Do you know personally anyone who has been attacked by a lion?” | Nominal categorical: *Yes (43%), No (57%)* | ✓ | | ✓ | |
| Participation in the project’s conflict mitigation programmes: Whether have bomas, guardians, both or neither | Nominal categorical: *Guardians only (70%), Bomas and guardians (4%), Neither (26%)* | ✓ | | ✓ | ✓ |
| Proportion of life spent in Hwange | Continuous numeric: *Age divided by years lived in Hwange* (range =0.01-1) | ✓ | | ✓ | |

| | | | | |
|---|---|---|---|---|
| Conflict level: The number of livestock lost and injured per village (statistics collected by Trans-Kalahari Predator Programme) | Continuous numeric (range = 0-137) | ✓ | ✓ | ✓ |
| Experience of other wildlife damage: "Have you suffered any of the following to yourself or in the close family last 12 months? Crop raiding (by elephants, baboons, quelea birds, bush pigs, cattle or similar)" | Nominal categorical: *Yes (66%), no (34%)* | ✓ | ✓ | |
| Level of fear of lions: "To what degree does fear of lions interfere with your daily activities? (such as going to school, fetching water, going to visit friends or relatives, or other activities)" | Ordinal categorical: *Doesn't interfere at all (12%), Barely interferes (9%), Moderately interferes (20%), Severely interferes (21%), Very severely interferes (38%)* | ✓ | | ✓ |
| Perceived frequency of lion incursion onto village land: "How often do you think lions come onto your village lands?" | Ordinal categorical: *Never (7%), A few times per year (10%), Every month (19%), Every week (61%), Every day (3%)* | ✓ | | ✓ |
| Ecocentric values regarding lions: "To what extent do you agree with the following statement: lions have the right to exist" | Ordinal categorical: *Strongly disagree (3%), Somewhat disagree (4%), Neither agree nor disagree (10%), Somewhat agree (51%), Strongly agree (32%)* | ✓ | | ✓ |
| Degree of religious observance: "How often do you attend church or other religious ceremonies?" | Ordinal categorical: *Never (9%), Rarely (9%), Once a month (2%), Several times a month (5%), Once a week (53%), Several times per week (22%)* | ✓ | | ✓ |
| Belief in traditional religion: "How important do you think traditional ceremonies (such as rainmaking, ukuthethela and traditional memorial ceremonies) are for the wellbeing of your community?" | Ordinal categorical: *Not important at all (41%), Somewhat important (8%), Moderately important (8%), Very important (24%), Extremely important (19%)* | ✓ | | ✓ |
| External responsibility for risk: "Who do you think is responsible for your losses to predation?" | Open question categorised into a binary nominal categorical variable: *Somebody else is responsible (69%), Nobody else is responsible (31%)* | ✓ | | ✓ |
| Whether respondent has ever lost livestock to lions: "Have you ever lost livestock to lions?" | Nominal categorical: *Yes (39%), No (60%), Not sure (1%)* | ✓ | | |

| | | |
|---|---|---|
| Perceived degree of benefits accruing from the protected area: “To what degree do you feel that your household benefits from the presence of Hwange National Park?” | Ordinal categorical: *Don't benefit at all (69%), Benefit a little (11%), Moderately benefits (12%), Benefit strongly (6%), Very strongly benefits (2%)* | ✓ |
| Perceived relative wealth: “How do you feel your wealth compares with the rest of your village?” | Ordinal categorical: *A lot worse (5%), A bit worse (22%), About the same (22%), A bit better (49%), A lot better (2%)* | |

3.3.4. Data exploration

Scatterplots (numeric variables), bar graphs (categorical and numeric variables) and box-and-whisker plots (categorical and numeric variables) were used to detect outliers which were checked for transcription errors. Outliers that could not be attributed to transcription errors were not removed. Summary statistics (number of values, number of null values, min, max, range, sum, median, mean, SE mean, confidence interval of the mean, variance and standard variation) were calculated for all variables.

We plotted the response variable against all predictors. We plotted the raw data of every variable against the response variable. For ordinal variables, we constructed stacked bar plots, while for nominal and continuous variables we constructed box-and-whisker plots.

We carried out factor analysis for mixed data (FAMD) to explore the potential for reducing the number of variables by generating summary factors, but the axes generated did not summarise a substantial part of the total variability

3.3.5. Choice of models

We used the clmm function in the package "ordinal" (Christensen, 2018) in R version R-3.5.3 (R Core Team, 2019) to fit ordinal logistic regression mixed models, treating "village" as a random variable to account for the spatial clustering of respondents in each village.

We created models for three different purposes (Table 1). Attitude to coexisting with lions is the response variable in each model.

1. *Comprehensive model:* Investigating plausible effects of a wide range of variables on attitude to coexisting with lions.

2. *Management model:* For the purposes of practical conservation management in the areas surrounding Hwange National Park, we constructed a model that included only variables that can be readily observed or that are currently being recorded in the area. This is a predictive model that can be used by conservation managers to tailor the targeting of conservation programmes.

3. *Thematic models:* We constructed three thematic models to compare the explanatory power (adjusting for parsimony) of different kinds of variables: one model contained socio-economic variables, one model contained variables pertaining to beliefs and perceptions, and one model contained variables describing past experiences with lions or with lion conservation. There is debate in the human-wildlife conflict field about what types of factors explain attitudes to wildlife, with a recent trend of scepticism towards the adequacy of socio-economic variables (Skogen et al., 2013). The relative performance of the three thematic models in predicting the response was quantified using AICc as in Lindsey et al. (2017) (Table S11, Supplementary materials).

3.3.6. Assumption testing:

It is well established that collinearity among predictors is a problem for constructing linear models (Johnston et al., 2018). We quantified collinearity for all pairs of predictor variables. Since our data include continuous, ordinal and nominal variables, different methods were required for the different combinations of variable types. We focused on effect sizes rather than hypothesis tests as with large sample sizes (as here) unimportant effect sizes can be detected as statistically 'significant'. We ran Spearman's rank correlation test on all combinations of numeric and ordinal variables, with a correlation coefficient cut-off threshold of 0.70 identifying problematic collinearity (Dormann et al., 2013). We ran Kruskal-Wallis tests on combinations of numeric to nominal and ordinal to nominal variables. Combinations of nominal variables were examined using Cramer's V, with a cut-off criterion of 0.5. Values of Cramer's V above 0.4 and 0.6 indicates "relatively strong" and "very

strong" similarities among variables, respectively (Ellis et al., 2010, Rea and Parker, 2014). These three statistics are not comparable, as Spearman's and Cramer's V yield measures of degrees of association (Friendly and Meyer, 2015). These tests were used in combination with variance inflation factors (VIFs). VIFs above the value 10 indicate a serious collinearity problem (Lin, 2008). All VIFs for models presented here have VIFs below 2 (Tables S2 – S6), showing that there are not problematic levels of collinearity between any variables included in the same model.

We tested the proportional odds assumption of ordinal models both graphically and statistically (Liu and Zhang, 2018) and neither revealed any problematic breaches of the proportional odds assumption. We also tested whether the logit link function was appropriate by comparing QQ plots for models with different link functions.

3.3.7. Nested mixed models and clustering

1482 people were interviewed living in 593 different households. Individuals that share the same homestead are not independent samples, so to check for any clustering effect we created a nested version of every model, where individuals are nested within homesteads which are nested within villages, and used a likelihood ratio test to see if the nested models differed significantly from the non-nested models. They did not differ ($p>0.7$) so there was no statistically detectable confounding effect of the association of individuals within homesteads

3.3.8. Approach to statistical significance and strength of evidence

Through this thesis I have followed the approach towards statistical significance outlined by Amrhein et al. (2019). It is a statement with more than 800 signatories, which calls for a move away from significance thresholds and towards reporting degrees of strength of evidence. Throughout this thesis I report results according to degree of evidence for an association with the response variable. In the results tables this is indicated with the symbols "." (indicates very low significance level), "*" indicates low level, "**" indicates intermediate level, and "***" indicates high significance level.

There is no cut-off level, only degrees of strength of evidence. P-values < 0.1 will be considered evidence that is adequately strong to be worth discussing, as is common in the field of economics (e.g. Goerke and Pannenberg (2015), Schläpfer (2006), Mourato and MacKerron (2010), Bakhshi et al. (2015), Perez Loyola et al. (2021), Armstrong et al. (2019), Fang et al. (2021), Milovanska-Farrington and Farrington (2021), Kumagai (2021), Baldursdottir et al. (2021), Krys et al. (2021), Faccioli et al. (2020), Dardanoni and Guerriero (2021)). To make the strength of evidence clear, the p-value is given not only in the results tables but also as part of the text in the results section. Furthermore, when discussing the variables in the discussion section, the strength of the evidence is mentioned when relevant. Note that the strength of influence of a variable on a model does not relate to p-values but to effect sizes.

## 3.4. RESULTS

A total of 1482 people participated in the survey, and 1478 remained after excluding incomplete entries. 97% of people asked to participate complied. Everyone was interviewed individually, without other people present. Forty-four percent of the participants were male and 56% female. Fifty percent of participants attached moderate or greater importance to traditional religion. The median attitude score for coexisting with lions was 'negative', on a scale ranging from very negative to very positive. Seventy-eight percent of people stated that there were no positive aspects of having lions in their area. Thirty-nine percent of participants stated they had experienced livestock loss to lions, 60% had never lost livestock to lions (the remainder were unsure). Ninety percent of people owned livestock, the mean number of livestock lost to lions in the last three years was 2. The median personal wealth was US$1059 (interquartile range = 486 - 2152). Most people were covered by the mobile boma (18%) or community guardian programme (52%), 5% were covered by both, and 25% were covered by neither programme . Fifty-two percent of participants had never seen a lion

but 43% of participants personally knew someone who had been attacked by a lion. Sixty-four percent of participants thought lions came into village lands every week or more often. The median response to the question of to what degree fear of lions interferes with their daily activities was "Severely interferes" (38% of respondents). Thirty-one percent of participants perceived there to be some benefits to their household from the presence of the national park. Eighty-three percent of participants thought that lions have the right to exist.

3.4.1. Comprehensive model

There was evidence that women's attitudes to coexisting with lions were slightly more negative than those of men ($p = 0.06$). There were differences in attitude among ethnicities, with Tonga being most negative ($p = 0.01$). Older people were more negative ($p = <0.01$), and higher levels of education were weakly associated with more negative attitudes ($p = 0.07$). Having lost lost more livestock to lions in the last three years were more negative than those who had lost less ($p = 0.04$), as were those who had spent a higher the proportion of their life in Hwange ($p = 0.01$). Respondents who reported seeing lions more often were more negative ($p = 0.01$). Respondents who perceived that lions enter village lands at higher frequency had more negative attitudes ($p = 0.04$), as did respondents who personally knew someone who has been attacked by a lion ($p = 0.02$). Respondents who reported that fear of lions interferes with their daily activities to a high degree were more negative ($p = <0.001$) (Table 2). The order of categories for each variable is presented in Table 1.

Conversely, the number of dependants a person provides for was associated with more positive attitudes ($p = 0.03$), the more importance a person places on traditional religion (animism and ancestor worship) the more positive they were ($p = 0.09$), and people who perceive more benefits accruing to their household from the presence of Hwange National Park were more positive ($p = <0.001$). Higher levels of ecocentricity were associated with more positive attitudes ($p = <0.001$). Participation in the conservation programmes of the TKPP seemed to be having a positive effect on

attitudes. People who had access to community guardians were more positive than people who were not covered by either the mobile boma or lion guardian programme ($p = 0.05$), while people who had access to both community guardians and mobile bomas were the most positive compared to those who had no bomas or guardians ($p = <0.001$) (Table 2).

Of the 15 factors with evidence for a relationship with attitudes towards coexisting with lions, five related to tangible variables (whether objective or perceived): number of livestock lost, whether someone they personally knew had been attacked by lions, perceived frequency of lions entering the village, how often they have seen lions, and whether they participated in the community guardian or mobile boma programmes. Four variables related to intangible factors: fear (as measured by degree of interference of fear on daily activities), ecocentric values, traditional religion and how rooted the individual was in the Hwange area (indicated by the proportion of life spent in Hwange). One variable, the degree to which the household benefits from the national park, might contain a mix of tangible and intangible values. The remaining five variables related to demographic characteristics: age, gender, education, ethnicity and number of dependants.

Several factors that have been found to be influential on attitudes in other systems did not show a relationship with attitude to coexistence with lions. There was no evidence for any association between attitudes and whether or not the person owned livestock, the number of livestock owned, degree of dependence on livestock for income, the total number of livestock killed or injured in the village area between 2008 and 2019, or whether or not the person blames someone else for their livestock losses. Some personal characteristics were unrelated to attitude: health, material satisfaction, wealth and perceived relative wealth. Similarly, variables relating to costs and benefits from wildlife presence; being employed in wildlife-related work or experience of wildlife-related harm (other than lions) were unrelated to attitude. Frequency of participation in religious activities was not associated with attitude (Table 2).

Table 2. Coefficients, standard error (SE) and p-values of the comprehensive attitude model. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001). The response variable was a Likert-type item ranging from "very negative" to "very positive" on a five-point scale in response to the question "How do you feel about having lions in your area?". The effect size column displays average effect size of explanatory variables across all levels of the response variable.[1]

| Variable | Estimate | SE | P-value | * | Effect size |
|---|---|---|---|---|---|
| Gender Female (reference level: "male") | -0.25 | 0.13 | 0.06 | . | 0.02 |
| Ethnicity Nambya (reference level: "Ndebele") | 0.04 | 0.18 | 0.81 | | |
| Ethnicity Tonga | -0.53 | 0.20 | 0.01 | ** | <0.01 |
| Ethnicity other | -0.01 | 0.25 | 0.98 | | |
| Age | -0.01 | <0.001 | <0.01 | ** | 0.05 |
| Owns livestock (reference level: "does not own livestock") | -0.27 | 0.24 | 0.25 | | |
| Number of livestock lost | -0.03 | 0.02 | 0.04 | * | 0.07 |
| Education | -0.41 | 0.22 | 0.07 | . | 0.03 |
| Physical condition | -0.28 | 0.21 | 0.18 | | |
| Total wealth | -1.45 | 2.79 | 0.60 | | |
| Number of livestock owned | 0.03 | 0.02 | 0.30 | | |
| Proportion of non-animal wealth | 0.21 | 0.27 | 0.44 | | |
| Satisfaction with material circumstances | -0.35 | 0.22 | 0.10 | | |
| Perceived relative wealth | -0.06 | 0.20 | 0.77 | | |

[1] The order of categories for each variable is presented in table 1.

| | | | | | |
|---|---|---|---|---|---|
| Total number of livestock killed or injured in the village area between 2008 and 2019 | <0.001 | <0.001 | 0.95 | | |
| Employment in wildlife work (reference level: "not employed in wildlife work") | -0.18 | 0.14 | 0.22 | | |
| No ownership of wealth (reference level: "full ownership of wealth) | 0.04 | 0.16 | 0.81 | | |
| Partial ownership of wealth | 0.02 | 0.15 | 0.88 | | |
| Number of dependants | 0.07 | 0.03 | 0.03 | * | 0.07 |
| Proportion of life spent in Hwange | -0.44 | 0.16 | 0.01 | ** | 0.03 |
| Programme participation: only guardians (reference level: "Both guardians and bomas") | -0.52 | 0.27 | 0.05 | . | |
| Programme participation: neither guardians or bomas (reference level: "Both guardians and bomas") | -1.08 | 0.31 | <0.001 | *** | 0.09 |
| Frequency of seeing lions | -0.30 | 0.12 | 0.01 | * | 0.03 |
| Do not personally know someone who has been attacked by lion (reference level: "personally know someone") | 0.29 | 0.13 | 0.02 | * | 0.02 |
| Experienced other wildlife-related harm (reference level: "not experienced other wildlife-related harm) | -0.16 | 0.12 | 0.16 | | |
| Perceived household benefits from national park | 0.69 | 0.18 | <0.001 | *** | 0.07 |
| Fear | -1.39 | 0.14 | < 0.001 | *** | 0.15 |
| Ecocentricity | 0.76 | 0.20 | <0.001 | *** | 0.06 |
| Frequency of participation in religious activities | -0.18 | 0.16 | 0.25 | | |
| Belief in traditional religion | 0.19 | 0.11 | 0.09 | . | 0.02 |
| Nobody is responsible for losses to lions (reference level: "someone else is responsible for losses to lions") | 0.18 | 0.12 | 0.13 | | |

| | | | | | |
|---|---|---|---|---|---|
| Perceived frequency of lions entering village lands | -0.47 | 0.22 | 0.04 | * | 0.05 |
| Whether respondent has ever lost livestock to lions | 0.04 | 0.14 | 0.77 | | |

3.4.2. Effect sizes in the comprehensive model

Table 2 presents average effect sizes, calculated from marginal effect sizes (Fox and Weisberg, 2018). This is the average of the differences in effect size between the highest and lowest end of the range (made positive for the purposes of averaging) at every level of the response variable. Among the variables with above average effect sizes (the average effect size of the variables in the model was 0.05), two related to tangible factors: number of livestock lost and participation in the community guardian and mobile boma programmes. Two related to intangible factors: ecocentricity and the interference of fear. One captured both tangible and intangible benefits: benefits to the household from the presence of the national park. The last variable was a demographic characteristic: number of dependants (average effect sizes for the explanatory variables associated with attitude to coexistence with lions are shown in Table 2).

3.4.3. Management model

The evidence emerging from this model was, as expected, similar to that observed in the comprehensive model. Ethnicity was found to be associated with attitudes to coexistence with lions, with Tonga people being more negative relative to Ndebele as the reference level ($p = 0.01$).Older people were found to be more negative ($p = <0.001$), and the number of livestock lost displayed a negative relationship with attitude ($p = <0.001$). People who were not participating in either the mobile bomas or the community guardian programme were more negative ($p = <0.001$). There was no evidence for the total number of livestock killed or injured in the village area between 2008 and 2019 or gender being useful predictors of attitudes to lions (Table S7, Supplementary Information).

### 3.4.4. Thematic models

We compared three thematic models: one containing socio-economic variables, one model with variables pertaining to beliefs and perceptions, and one based on past experiences with lions and conservation (Table S8-S10, Supplementary materials). The beliefs and perceptions model was the best performing thematic model, while the comprehensive model was the overall best performing model (Table S11, Supplementary materials).

## 3.5. DISCUSSION

Our findings lend support to calls for increased focus on the more intangible factors associated with conflict and coexistence (Barua et al., 2013, Pooley et al., 2017), and question the supremacy of material costs and benefits.

Our comprehensive model shows that intangible factors are as important as tangible factors, if not more important. A sizeable portion of the 15 variables with robust evidence for a relationship with attitudes towards coexisting with lions related to intangible factors. Five related to tangible factors, four related to intangible factors, while one variable plausibly contained a mix of tangible and intangible values. The remaining five variables related to demographic characteristics. The strength of the effects of these variables further support the importance of including intangible factors to understand attitudes to human-wildlife coexistence. As many intangible as tangible factors were in the top tier of effect sizes (fear and ecocentricity were the most influential intangible variables). The degree to which fear affects respondent's daily activities had the strongest effect of all variables by a large margin (Table 2). The effect size for fear was clearly larger than that of the tangible livestock loss, while the effect size of ecocentricity was only slightly lower than that of livestock loss (the p-values of both fear and ecocentricity were $< 0.001$). We measured the level of fear by asking to what degree fear of lions interferes with the respondents' daily activities, as fear is a multidimensional concept so the question should be situationally specific to ensure comparability

between respondents. The question captures the direct psychological cost of fear but also the indirect opportunity costs resulting from feelings of fear. It is possible that some respondents carried out daily activities without interference out of necessity, so the effect of fear might even be an underestimation, and it does not capture every aspect of fear.

Fear constitutes a cost (Johansson et al., 2016), and our results lend support to some of the conclusions reached in the meta-analysis by Kansky et al. (2014) which found tangible costs and benefits to be of lower importance than expected, and that intangible costs was the most important category to explain attitudes. However, some of the variables with robust evidence for association with attitudes in our study do not directly relate to costs or benefits. Instead they relate to the world-view and values of the person (traditional religion and ecocentricity), or could plausibly be related to world view, values and beliefs (age and ethnicity). Ecocentricity was significant at a high threshold (<0.001), age and ethnicity (Tonga) were significant at an intermediate level (<0.01) and traditional religion was significant at a very low level (<0.1). Note that the terminology "very low level" is only relative to the higher significance levels. One of the variables among those with the highest effect sizes was composed of a mix of tangible and intangible values and requires a more complex interpretation. The variable pertaining to the perceived benefits to the household from the presence of the national park was composed of both tangible and intangible value. During the qualitative interviews, participants named both tangible benefits, such as tourism and employment, and intangible benefits, such as maintenance of lions for their existence value. However, though the effect of such benefits was high, the number of people perceiving such benefits was low: only 31% of participants perceived there to be any benefits. The p-value of this variable was <0.001, so the evidence for a relationship is very robust.

Only one socio-economic characteristic displayed an above average effect size: number of dependants (and the strength of the evidence was low ($p = 0.03$) on the scale of values considered statistically probable enough to reveal a real relationship to warrant discussion). Most of the socio-

economic variables displayed higher effect sizes in the model that included only socio-economic variables than they did when part of the comprehensive model (Table S12, Supplementary materials). Furthermore, in the model with only socio-economic variables, some variables appeared significant (the person's total wealth, proportion of non-animal wealth, and satisfaction with material circumstances) that were not significant when controlling for a wider range of factors in the comprehensive model (Table 2, and Table S8, Supplementary materials). This raises questions about the prevalence of socio-economic variables in studies attempting to understand human-wildlife relationships, and show that it is important to only use such models for predictive purposes to avoid falling to the temptation of concluding that socio-economic variables explain underlying mechanisms that shape attitudes.

To illustrate the misleading results of the focus on socio-economic variables that has been predominant in the human-wildlife field for much of its history, we compared the performance of three thematic models: one model containing socio-economic variables, one using variables pertaining to beliefs and perceptions, and a third containing variables describing past experiences with lions or with lion conservation. Of the three, the model containing only variables relating to beliefs and perceptions performed best (Table S11, Supplementary Information). If someone wishing to predict attitudes to lions were to focus on just one type of variable, focusing on beliefs and perceptions would inform conservation efforts more effectively than socio-economics. However, the most informative approach is, of course, to incorporate a range of variables of different types, and our comprehensive model far outperformed either one of the thematic models so we focus on the results of this model (Table 2).

The two paragraphs above demonstrate that focusing on sub-sets of variables in isolation, such as socio-economic variables, can yield misleading results that are revealed when controlling for a larger number of variables. Therefore, the specific results of the three thematic models are of lesser interest. However, if one were to focus on the message of each of the thematic models, the key

findings would be: the number of livestock lost and age display the strongest signal in the socio-economic model ($p < 0.001$), while employment in wildlife work unexpectedly insignificant ($p > 0.1$). In the model of beliefs and perceptions, fear, ecocentricity and perceived frequency of lions entering village lands all have a high level of association with the attitude to co-existence with lions ($p < 0.001$). In the model relating to the past experiences with wildlife and conservation, participation in the mobile bomas and lion guardians was highly associated with attitude to co-existence ($p < 0.001$) if not participating in either bomas or guardians), and so was number of livestock lost ($p < 0.001$) and personally knowing someone who had been attacked by lions ($p < 0.001$). The use of these results for conservation practice is limited to identifying target groups that are statistically likely to hold negative attitudes towards living alongside lions. These results are not suitable for making recommendations on how to change attitudes, as the comprehensive model shows that many of these apparent effects disappear when controlling for a larger range of variables. The comprehensive model is more suitable for supporting hypothesised causal relationships which can form the basis for conservation strategies.

Since livestock losses are traditionally believed to be key to human-carnivore conflict, we aimed to disentangle different aspects of livestock loss and livestock ownership with the comprehensive model. We hypothesised that factors that reflect the risk of livestock loss or vulnerability to livestock loss would be influential. Previous studies have found conflicting results regarding the influence of livestock variables, perhaps due to differing choices in how to define the livestock variable used in their models. Koziarski et al. (2016) found no effect of livestock ownership, while Tessema et al. (2010) found that owning fewer livestock was associated with positive attitudes, and Mitchell et al. (2019) found attitudes to lions to be in proportion to their involvement in livestock predation.

The psychological relationship between owning livestock and attitude towards lions has not previously been explored comprehensively. We hypothesised that the relationship might plausibly operate in a linear way that scales with the number of livestock owned or lost to predation, or as a

categorical mental state (whether or not the person owns livestock and whether the person has ever lost livestock). Only one linear measure, number of livestock lost over the last 3 years, was associated with attitude (at a relatively low significance level of p=0.04). The effect of this variable on attitude was strong, only exceeded by the effect of fear on people's daily activities, while being similar to the effects of perceived benefits from the national park, the number of dependants and ecocentricity. The overall conflict level (as indicated by total number of livestock killed or injured in the village area between 2008 and 2019) of the village was not associated with attitude, indicating that personal losses are more likely drivers of attitudes. A previous study in Hwange found no relationship between livestock losses and desired change in lion population numbers when looking at livestock losses incurred over the last year (Western et al., 2019), indicating that such effects may operate over a longer time-frame. However, as the strength of evidence is relatively low on the scale of acceptable evidence (p=0.04), the possibility of type I error should be kept in mind (Agresti and Finlay, 2009). We also hypothesised that risk and vulnerability might affect attitudes to coexisting with lions, but variables relating to an individual's risk (whether respondents owned any livestock, how many livestock they owned) or vulnerability to livestock losses (how dependent they were on livestock for income and their total wealth) were not found to be associated with attitude.

Two variables with evidence for a relationship with attitude related to the dimension of time: age and the proportion of the respondent's life spent in the area around Hwange National Park (both were at the same intermediate significance level with p-values < 0.01). We used the latter as an indicator of how much of the person's life experiences had been shaped by living alongside lions in this area. Both were associated with more negative attitudes to coexistence. The age variable on its own would be difficult to interpret: the cause of the negative effect could either be that increased time lived alongside lions induces more negative attitudes, or that younger generations hold more positive views on lions. Studies within the field of human-wildlife coexistence frequently find that age is associated with more negative attitudes (Dickman et al., 2013, Zimmermann et al., 2005,

Suryawanshi et al., 2014, Røskaft et al., 2003, Thorn et al., 2012, Campbell and Lancaster, 2010, McKay et al., 2018). However, when seen in context of the variable describing the proportion of life spent near Hwange National Park and the negative effect of the frequency of seeing lions, our interpretation is that increased exposure to lions induces more negative attitudes. Possibly, the mechanism for this is the accumulation of personal experiences and stories of attack and livestock loss creating a social environment that is hostile to lions. Mkonyi et al. (2017) found that residency time was associated with higher levels of self-reported depredation in Tanzania.

One of the influential variables in the comprehensive model, the number of dependants, had an effect that was contrary to our expectations. We hypothesised that a higher number of dependants would lead to higher vulnerability to lion attack, and therefore more negative attitudes to coexistence with lions. However, attitudes were more positive among respondents with more dependants (Table 2This could be at least partly explained by the observation that one of the few benefits of lions that people expressed in qualitative interviews was the desire for lions to exist for children to see and know. This variable was significant at $p = 0.03$, which is classified as “low” on the range of strength of evidence.

The factors that were not found to be associated with attitudes towards coexistence are also of considerable interest. We tested several wealth variables: absolute wealth, satisfaction with own material circumstances, and perceived relative wealth compared to the individual’s neighbours. The latter variable was included as an alternative wealth metric as the econometric literature frequently finds that the perceived level of wealth relative to a person’s community is more influential on attitudes and mental states than actual wealth (Luttmer, 2005). There was no evidence for an association with these wealth variables. Similarly, employment in wildlife work is often believed to improve attitudes towards wildlife (Walpole and Thouless, 2005), but we did not find any evidence for that here. We also tested whether blame and perceived responsibility for livestock losses affected people’s attitudes. There was no robust evidence that people who assigned responsibility

for livestock losses to someone else (e.g. the government, the national park or conservationists) were more negative to coexisting with lions.

Physical vulnerability has been offered as an explanation for the greater prevalence of negative attitudes towards carnivores among women and elderly people that has been demonstrated elsewhere (Røskaft et al., 2003). We tested this by including a metric of physical condition. We also hypothesised that experiences of damage caused by other wildlife could lead to a spill-over effect of intolerance towards lions. We formed the novel hypothesis that lack of ownership of household wealth would be associated with less negative attitudes towards lions, as an individual might discount possible losses to lions in proportion to the benefits they would actually be able to access from the value of the livestock. Ownership of a resource has been shown in other contexts to affect attitudes (Mbaiwa and Stronza, 2011). None of these three hypotheses were supported by our results.

3.5.1. Project evaluation

In response to the calls for increased evidence-based evaluation of conservation practices (Sutherland et al., 2004), we explicitly incorporated project evaluation into this investigation. The TKPP runs two conflict mitigation programmes with the intention of improving attitudes towards coexistence with lions, as lions sometimes cause harm to local people (physical and psychological harm) and people sometimes persecute lions. We found evidence for a relationship between attitudes to coexisting with lions and participation in these programmes. There was some evidence that people that participate in only the community guardian programme were more positive than those who did not participate in either programme and very strong evidence that people who participated in both were more positive to lions than people who didn't participate in either one. This does not unequivocally prove causation, as there is the potential of a self-selection effect where villages with people that have more positive attitudes are more likely to participate in the mobile bomas programme. However, the locations for the community guardian programme were selected

purely based on spatial location and conflict level (for which control variables are included in the model) so there was no scope for self-selection. The evidence for an association between the attitude to coexistence with lions and participating only in the community guardian programme was also very low on the scale of acceptable p-values which entails a higher probability for false positives (Type I error) (Agresti and Finlay, 2009). The positive association between participating in these programmes and attitudes is supported by the findings of (Sibanda et al., 2020) in the Hwange area.

The comprehensive model aims to achieve a nuanced understanding of the range of variables that are associated with attitudes towards coexisting with lions. Observational studies cannot determine causality, but there are other strands of evidence supporting plausible links here. In contrast, our management model is explicitly pragmatic and aims to inform conservation practitioners by allowing them to predict attitudes towards coexistence based on observable variables. This aims to help inform the engagement with key stakeholders with particularly negative attitudes to lion presence. Age, ethnicity, programme participation and numbers of livestock lost to lion depredation emerged as useful predictors (all these variables had p-values below a 0.05 threshold, giving acceptable confidence in their usefulness for predictive purposes).

## 3.6. CONCLUSION

Overall, our results show that intangible factors are important to understand attitudes towards coexisting with dangerous carnivores. They are at least as influential, if not more, as the socio-economic variables and livestock loss variables that have conventionally been assumed to be the main factors shaping attitudes in the field of human-wildlife conflict for much of its history. Furthermore, the focus on costs and benefits (whether tangible or intangible) should be tempered with greater inclusion of variables explicitly relating to values and beliefs. Our results carry implications for practical conservation policy. The effect of fear on people's daily life proved to be among the strongest correlates of people's attitude towards this large carnivore, with p-values

indicating very strong evidence. Johansson et al. (2016) review the evidence on interventions aimed at reducing fear of large carnivores and find that the evidence is scarce and contradictory. We recommend that mitigating fear, through education about the risk posed by lions (which is low in this area) and through practical safety measures to reduce the risk of attacks and minimise opportunity costs, should be a priority. There is also evidence that increasing knowledge can have a positive impact on attitudes (Glikman et al., 2012, Dickman et al., 2013, Feilen et al., 2018), so this provides an further reason for educational strategies. This education could be carried out by organising informational events by the TKPP, or by collaborating with schools to incorporate education about lions in their curriculum (for a more detailed discussion of education as a conservation strategy, its efficacy and potential unintended consequences, see section 5.5.1). The aim of education should not just be to improve attitudes through the transfer of knowledge but also by generating positive affect (Glikman et al., 2012)

Livestock loss does matter, but losses to the individual rather than the conflict level of the area seem to shape attitudes, though the strength of the evidence was low Reduction of livestock loss should therefore remain a priority, but further studies should be conducted to rule out the possibility of type I error. A strong association was found between positive attitudes towards lions and the perception of benefits accruing from the national park, so ensuring that local stakeholders benefit from the presence of the protected area should continue to be an important goal. There are several mechanisms that are used to ensure that communities that live on the borders of protected areas experience significant and relevant benefits. Tourism and trophy hunting can generate employment, and CAMPFIRE, a formal initiative for sharing the revenue from those activities, does operate in the area. Unfortunately the benefits generated do not reach the communities to a sufficient degree (Taylor, 2009, Tchakatumba et al., 2019). Sibanda et al. (2020) found that only 18% of the members of the three communities they surveyed (which included Mabale) perceived CAMPFIRE to be of direct benefit to them. Integrated Conservation and Development Programs (ICDPs), which link

conservation with social and economic development, have become increasingly popular worldwide (Coad et al., 2008). ICDPs vary in their outcomes, but notable successes include Bwindi Impenetrable Forest in Uganda and the Amboro National Park in Bolivia, which have improved local infrastructure, formalised traditional alternative livelihoods and improved education and health services (Hughes and Flintan, 2001). Payment for ecosystem services is another approach for linking conservation outcomes to benefits from maintaining natural areas. Beneficiaries (such as downstream users of water in a rainfall catchment, or international beneficiaries of the conservation of charismatic megafauna) pay for the maintenance of these services (Jack et al., 2008).

People with an ecocentric value orientation were much more positive towards coexistence with lions, but we know little about what shapes ecocentric attitudes in relation to lions. This influential piece of the attitude puzzle deserves further scrutiny.

Additional information on data exploration, assumption testing, variable choice, a priori hypotheses and effects sizes can be found in Supplementary materials.

**Statement of Authorship for joint/multi-authored papers for PGR thesis**

To appear at the end of each thesis chapter submitted as an article/paper

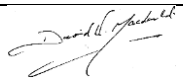
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|---|---|
| Title of Paper | Fear, ecocentricity and religion – intangible factors matter for human-lion coexistence |
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## Student Confirmation

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| Contribution to the Paper | I lead a team of research assistants to carry out data collection. Performed the analysis and wrote the manuscript.<br>Received help from Paul Johnson in figuring out the coding in R and the statistical tests.<br>Received help from Lovemore Sibanda to carry out field work in a culturally appropriate manner.<br><br>The remaining co-authors contributed with advice on methodology and strategy, facilitated fieldwork, and commented on the paper through its development. | | |
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## Supervisor Confirmation

By signing the Statement of Authorship, you are certifying that the candidate made a substantial contribution to the publication, and that the description described above is accurate.

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|---|---|---|
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# CHAPTER 4. What is a lion worth to local people – quantifying of the costs of living alongside a top predator

## 4.1. ABSTRACT

The presence of large predators entails a range of costs and some benefits for the communities that live alongside them. The cost in terms of the value of livestock lost to predation is well known, but

this represents only a part of the costs that people experience, as it does not account for intangible harms such as fear, avoidance behaviours and threat to human life. We quantify the total cost of lion presence for agro-pastoral communities in Zimbabwe using economic valuation techniques. The total value of a marginal lion was negative US$180 per person per year, which is several hundred times larger than the market value of the average per capita loss of livestock. If making simplifying economic assumptions, this discrepancy reveals the magnitude of the intangible costs associated with the presence of large predators, and conflict mitigation efforts that aim to compensate for only livestock losses are unlikely to be successful. However, not enough is known about the cognitive process used to relate costs to probabilities of loss and risk perception towards lion predation among participants to be certain. The disvalue of lion presence was linked to fear, ecocentric values, wealth and trust in compensation institutions. We also demonstrate the importance of considering heterogeneity in preferences within communities; segments of the population did not have net negative value attached to lions, and some disliked monetary compensation. We estimate the willingness-to-accept for two human-wildlife conflict mitigation programs in terms of acceptable increases in lion numbers, as opposed to monetary units which is the conventional approach in economic valuation studies. We argue that estimating value in terms of biodiversity outcomes should be used more widely. We also demonstrate the distorting effect of distrust towards compensation (measured by a likert-type item) in choice experiments and argue that economic valuation methods employing choice experiments should control for this distrust when estimating willingness-to-pay. These discoveries have relevance for a wide range of situations where potentially dangerous wildlife species co-exist with people.

## 4.2. INTRODUCTION

Conflict between people and wildlife is among the most severe threats to the survival of many species (Macdonald and Willis, 2013) and simultaneously among the most serious threats to

people's welfare in the affected areas (Dickman et al., 2011). Conflict is among the most critical threats to large carnivores worldwide (Ripple et al., 2014). Carnivores have global importance, not just because of the cultural and existence value placed up on them by people (Macdonald, 2001) but also because they have significant economic value (Macdonald et al., 2017a) and may serve as umbrella or ambassador species (Macdonald et al., 2017b). They also regulate ecosystem function and extirpation of apex carnivores is the most pressing environmental issue alongside climate change (Ripple et al., 2014). Yet few species have the ability to raise as fervent opposition as large carnivores, as they pose not only a threat to people's livelihood but are also perceived to pose a threat, whether real or misconceived, to human life (Thirgood et al., 2005). Because of the dual negative effects of such conflicts on both the wildlife in question and on the affected people, human-wildlife conflict simultaneously poses a conservation challenge and an environmental justice issue (Jacobsen and Linnell, 2016).

The material costs of living alongside large carnivores, both direct costs such as the value of depredated livestock (Holmern et al., 2007) and indirect costs such as herding (Herrmann et al., 2001) and buying fences (Schumann et al., 2006) are well understood. However, the intangible costs and benefits associated with living alongside carnivores have often been identified (Barua et al., 2013) but not quantified (and are most commonly ignored). Intangible costs and benefits include harms such as emotional harm (for example fear and stress) and benefits such as existence value or enjoyment from seeing wildlife (de Pinho et al., 2014). Understanding the full costs and benefits associated with living alongside wildlife is likely to be important to mitigate such conflict – though intangible costs are not observable they nonetheless may strongly influence stakeholders' attitude and behaviour. There have been repeated calls for research to elucidate these unobservable harms (Thirgood et al., 2005). It is difficult to envision effective alleviation of conflict without understanding the full scope of harms and benefits people experience, and how that influences their attitudes and behaviours. If the costs of coexisting with wildlife outweigh the benefits, people are likely to take

actions which may threaten wildlife populations (Dickman, 2009). We need a complete cost-benefit estimate of carnivore presence in order to effectively address human-wildlife conflict. Economic valuation techniques can be used to achieve this.

The central concept of economic value is that it measures the change in wellbeing that arises from a good or service (or disservice) (Bateman et al., 2002). Maintenance of large carnivores in protected areas can be seen as such a service/disservice. The limitation of carnivore valuation studies carried out so far is that most do not allow for negative willingness-to-pay (WTP). They therefore do not capture the value attached to carnivores in areas where the net value is perceived to be negative, such as is the case in areas with severe human-wildlife conflict. Examples of this includeChambers and Whitehead (2003), Håkansson et al. (2011) and Han and Lee (2008). Sutton et al. (2002) investigate WTP among communities that live alongside carnivores in Namibia and do allow for negative WTP values and estimate the general disvalue (negative value) of predator attack, however they do not estimate total value of the harm associated with predator attacks, as psychological costs are not included.

Lions exemplify the costs and the benefits associated with carnivores, as well as the threats they face from conflict. Conflict ranks among the top 4 threats to lions across Africa (IUCN, 2006a). Lions are capable of incurring the full range of costs on local communities, ranging from mere inconvenience to tragic loss of human life (Packer et al., 2019). The communities living alongside Hwange National Park in Zimbabwe (HNP) have experienced the full spectrum of such harms. Conflict with people is responsible for a significant proportion of mortality in the lion population in HNP and caused 19% of mortality of collared lions between 1999 and 2007 (Loveridge et al., 2010). Some stakeholders also perceive benefits associated with lion presence. Lions hold cultural value and are seen as a draw for tourism and associated income (Ghosh and Uddhammar, 2013). Dickman (2009) found that even though lions were seen to be the most problematic species to co-exist with, they were also the species that people around Ruaha National Park in Tanzania most often thought

should remain around for the sake of their children. Lions embody the complex mixture of tangible and intangible costs and benefits associated with carnivores. We provide an estimate of the full costs of living alongside lions, and cast light on the magnitude of the harms that must be mitigated in order to alleviate human-wildlife conflict (HWC) and address the grievances of the communities living alongside lions. Unlike previous economic valuation studies of carnivores, we explicitly tackle the costs by using a value-neutral method as opposed to value-elicitation formats that assume that values are positive, and therefore provides crucial information for human-carnivore conflict in general. Furthermore, previous economic valuation studies focusing on carnivores have only estimated the total value, not isolated the proportion of value attributable to intangible costs and benefits. We isolate the proportion of total value that is estimated to derive from intangible costs to provide the first estimate of the magnitude of intangible costs of carnivore presence. We also estimate the economic value of two conflict mitigation programs, mobile bomas and community guardians, to see which is most valued by the communities and compare the cost-benefit ratio of the programs.

This economic value estimate also fulfils another purpose. The death of Cecil the lion revealed that the global public attaches large existence value to lions (Macdonald et al., 2016), but there is a discrepancy between the beneficiaries of such existence value and the people who bear the costs of maintaining populations of large carnivores, i.e. the local communities (Nelson, 2009). The dollar value that we estimate shows how much the global public would have to compensate communities to offset the negative externalities caused by lion presence. Though such a payment scheme is unrealistic and without precedent, it does serve as a useful indication to conservation practitioners and the global public of the shortfall of benefits perceived by the communities that live alongside lions.

## 4.3. METHODS

### 4.3.1. Assumptions and theoretical framework

Choice experiments are embedded in random utility theory, first proposed by Thurstone (1927) and significantly developed by McFadden, e.g. McFadden and Zarembka (1974), McFadden (1986) and (McFadden and Train, 2000). Random utility theory poses that when making a decision between a set of alternatives, an individual will choose the one that provides the highest utility (Upton et al., 2012). According to random utility theory, utility is a latent construct that exists in the mind of the individual but cannot be fully observed by researchers (Louviere et al., 2010). The utility of each alternative can be divided into an observable portion and a stochastic element, and probabilistic statements can be made about preferences for the different alternatives (Upton et al., 2012). The stochastic component contains all the identified factors that influence choices as well as variability between individuals (Louviere et al., 2010).

The multinomial logit model and the latent class model are the models used to determine the utility of different choices in this chapter.

### 4.3.2. Study site:

The study area encompassed 20 villages in the Mabale area of Hwange Communal Land on the border of HNP in Zimbabwe. Subsistence agro-pastoral activities is the main livelihood strategy (Loveridge et al., 2017a). The Trans Kalahari Predator Programme (TKPP) runs the community guardian programme, which employs local individuals to advise the communities on livestock protection as well as chasing lions (and other predators) back into the national park if they stray onto village lands (Petracca et al., 2019). Lions that venture onto village land pose a threat to livestock and are vulnerable to being killed or injured by people (Loveridge et al., 2017b). TKPP also

runs a mobile boma programme, which provides bomas (protective cattle enclosures) to communities to keep livestock safe during the night. The mobile bomas are constructed from opaque PVC sheeting and are predator proof, unlike the traditional wooden corrals which are vulnerable to predators (Loveridge and Hunt, 2016). The mobile bomas have the additional benefit of concentrating the manure from the livestock and provide fertile ground that can be used for maize cultivation as, unlike traditional stationary corrals, they can be moved at regular intervals (Loveridge and Hunt, 2016).

### 4.3.3. Description of the choice experiment

Choice experiments is a well-established method used in the field of economics to quantify the economic value of goods where there exist no market values, such as cold-water corals (Armstrong et al., 2019). This provides a method for quantifying the full range of costs and benefits associated with carnivores, including the seemingly unmeasurable intangible costs and benefits (Bennett and Adamowicz, 2001). Choice experiments allow us to estimate the value of the marginal lion, which represents the sum of negative and positive values that people perceive as arising from each additional lion in their area. This sum can be net negative or net positive, depending on whether positive or negative values predominate.

In the choice experiment, participants were asked to choose between two different experimentally designed scenarios that aimed to capture different aspects of lion conservation and the status quo (which implied no change from the current situation). An example choice card is shown in Figure 1. Each scenario was described by four different attributes taking on different levels. The “number of lions” attribute captured the potential future change in the lion population, the “mobile bomas” and “community guardians” attribute captured the presence of each conflict mitigation programme respectively, and “monthly compensation” captured the compensation a participant would require to accept the proposed scenario. Each respondent made six choices and each choice implies a trade-

off between the attributes of the chosen and non-chosen alternatives. We used the information revealed by people's choices to estimate their utility functions and infer their preferences for lion conservation. We can use the estimated utility function to calculate the marginal rate of substitution between the non-monetary and monetary attributes. This is commonly referred to as willingness-to-pay (WTP) or willingness-to-accept (WTA), depending on whether they are asked to pay or accept compensation (Bennett and Adamowicz, 2001).

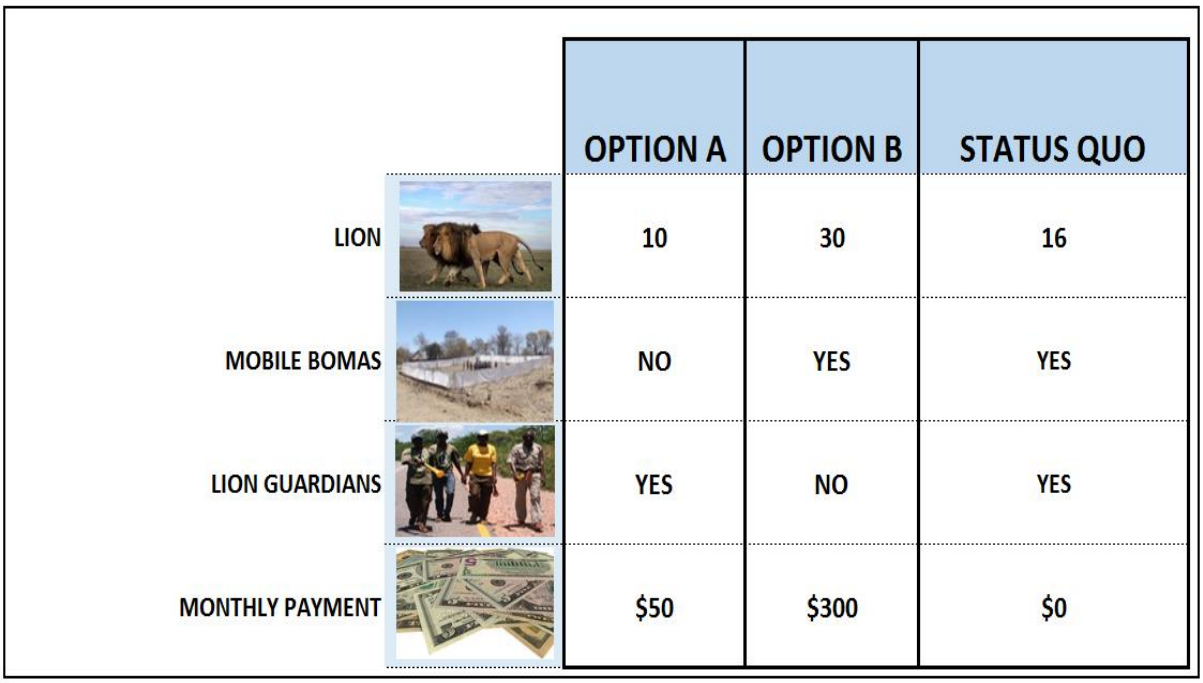



Figure 1. Example choice card (English translation)

4.3.4. Survey and choice experiment design process

An initial design for the choice experiment attributes, attribute levels and visual presentation was developed using academic literature and statistics on demographics, livestock husbandry, lion population levels and livestock losses to lions before going through three rounds of piloting in the field.

The "lions" attribute captures the number of lions in the area and ranges from 5 – 40 lions. This range captures the full extent of realistic lion densities for the area. Separate coefficients for

increases and decreases in lion numbers were fitted in the model, as increases and decreases would entail coefficients of opposing signs. Therefore, the tables of coefficients in the tables show "Decrease in lion numbers" and "Increase in lion numbers" rather than "lions".

The attributes "mobile bomas" and "community guardians" refers to the presence of each conflict mitigation program and were included to derive the value that stakeholders attach to these initiatives for program evaluation purposes. These attributes could take on the values "yes" or "no" indicating whether or not the measure was present. The final attribute, "monthly payment", captures the compensation required to accept each scenario and allows us to estimate economic value as part of our analysis. The levels of the compensation attribute ranged from US$0 to US$300 and were chosen to cover the range of value of livestock losses recorded in the area (Loveridge et al., 2017, Supplementary Information).

To define the status quo levels, we estimated the average number of lions living within the park, in close enough proximity that they could potentially reach village lands. Based on the last 5 years (2001-2015) of lion population data (Trans-Kalahari Predator Programme, 2001-2016), the average number was 16 lions. Attribute levels are summarised along with the results in Table 2.

Compensation was presented as a monthly payment, as opposed to an annual payment, because the pilot study revealed that participants were less confident that they would receive the compensation if the waiting period was too long due to the instability of the financial situation in Zimbabwe. This would undermine their belief in the hypothetical scenarios.

During the piloting process (which is detailed in the next section), each participant was asked questions to gage what they perceived to be a suitable range of payments. This revealed that many participants did not think in terms of average losses (i.e. how much they were likely to lose on an average year) but were instead thinking in a worst-case-scenario way: they only accepted payments high enough to offset the worst realistic damage so that they would be fine in a catastrophic year,

even though this might mean losing out on monthly payments in an average year. We therefore adjusted our range of payments upwards to account for this. WTA was chosen rather than WTP because the exploratory interviews and conversations with project staff revealed that people in the area object strongly to the notion of paying to reduce the lion numbers as many think that this is the responsibility of the government, national parks authorities or conservation organisations (while some point out that they can just kill the lions themselves for free).

The status quo for the attributes “mobile bomas” and “community guardians” differs depending on the conditions of each participant (some will have none, either one or both). Therefore, the respondent was asked whether he/she kept cattle in a mobile boma and whether there where community guardians covering the village and presented with the corresponding status quo scenario.

We used NGENE software 1.1.2 (ChoiceMetrics, 2016) to generate a d-efficient experimental design (d= 78) in order to optimise the amount of information that could be extracted from the choices made by the participants (Rose and Bliemer, 2009).

4.3.5. Piloting

The piloting was carried out in villages in the Mabale area, but not in the same villages where data collection were to take place. The choice cards and accompanying questionnaire were translated into the three main languages of the Mabale area (Ndebele, Nambya and Tonga) with convergence validity tests between the three languages for each question. All translations were then subject to a further check by one of the authors (L.S.), who is fluent in all three languages, to make sure there were no divergences in the content and nuance of the words and phrases. There are other minority languages present in the region, but it is extremely rare for someone not to be fluent in at least one of the three main languages, and we did not encounter anyone in that situation, so language was not a barrier to participation, and did not cause any biased selection effects in our study. The initial

design of the choice experiment was piloted in the field site by presenting the CE and associated questionnaire to participants, with each step accompanied by questions about the participant's view on the content of the question, the phrasing and the visual presentation. This was followed by open ended questions asking whether the participant could think of any additional points or issues that had not been addressed (the intention was to discover any omissions of issues that matter to the stakeholders in the area) or ways to improve the phrasing or presentation to make it easier to understand. The piloting examined every detail of the choice cards and questionnaire, from content to presentation, so the process was too fatiguing for one participant to pilot the entire survey. Therefore, each participant piloted one half of the survey in detail. At the end of this piloting period, new participants were presented with the full survey (but with less detailed questions) in order to discover any incoherencies that might be noticeable only when carrying out the full process. A second pilot was carried out a few weeks later to trial the revised survey after adjustment according to the findings of the first pilot. A third and final pilot was carried out directly proceeding the commencement of data collection as a final check and only very minor adjustments were required by that stage, making us confident about the content and presentation of the survey.

#### 4.3.6. Data collection

The data collection was carried out April- June 2017. The choice experiment were carried out along with the rest of the survey on tablets using the Qualtrics surveying platform (Qualtrics, 2017) by a team of 6 trained interviewers employed solely for the purposes of this survey, 1 of which was female and 5 were male. The aim was to have 3 female and 3 male interviewers, but only 2 females applied for the position and one dropped out after having been offered the position. The interviewers were all from the region and spoke one or more of the local languages fluently. As this

survey was carried out by the TKPP, there is a risk of strategic behaviour when answering the questionnaires. The villages we visited were drawn randomly from all the villages in the Mabale area within 30km of the border of the national park. The 30km cut-off was chosen because that corresponds with the scale of lion ranges in this area. Dispersing lions may move further, but such events are irregular. We attempted to interview every adult person in every household in the target villages. 1482 people were interviewed living in 593 different households.

Only people above the age of 18 and who were not under the influence of alcohol were interviewed. Prior informed consent was obtained from each individual according to the approved guidelines of Oxford University's Research Ethics committee (Ref. no. R49682/RE001).

Each participant was presented with 6 cards. The participants viewed the choice cards on the tablets. In the piloting stage we tried different numbers of cards, and found that presenting participants with more than 6 cards induced fatigue and reduced concentration for some participants. The variables that were used as interaction terms in the choice models were collected at the same time as the rest of the survey (Table 1).

Table 1. Variable types, question wording, answer scales and the specification format of the variables in the choice models

| Variable | Phrasing | Answer scale | Specification in models |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Ecocentric values regarding lions | "To what extent do you agree with the following statement: lions have the right to exist" | Ordinal categorical: Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree | Binary (dummy): Somewhat agree and Strongly agree = ecocentric |
| Level of fear of lions: | "To what degree does fear of lions interfere with your daily activities? (such as going to school, fetching water, going to visit friends or relatives, or other activities)" | Ordinal categorical: Doesn't interfere at all, Barely interferes, Moderately interferes, Severely interferes, Very severely interferes | Binary (dummy): Moderately interferes, Severely interferes, Very severely interferes = fearful |
| Trust in compensation | "A strategy that is sometimes used to try to reduce human-wildlife conflict is to offer monetary compensation to people who live near protected areas for damages caused by wildlife. How likely do you think this suggestion can be implemented?" | Ordinal categorical: 0 (Very unlikely), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Very likely) | Continuous |
| Wealth | Total sum of livestock production, crop production, income from formal and informal employment, and money sent from relatives abroad. | | Continuous (scaled by 100) |

#### 4.3.7. Data exploration

Using the FactoMineR package in R, we carried out factor analysis for mixed data (FAMD) to explore the potential for reducing the number of covariates by generating summary factors, but the axes generated did not summarise a substantial part of the total variability.

We ran Spearman's rank correlation test on all combinations of pairs of variables used as covariates in the models to quantify collinearity, with a correlation coefficient cut-off threshold of 0.70 identifying problematic collinearity (Dormann et al., 2013).

4.3.8. Model specification and estimation

We present both a simple multinomial logit model (MNL), and a more complex latent class model (LC) which incorporates preference heterogeneity (Greene and Hensher, 2003). This is to compare the results as a validity test and to illustrate the importance of recognising heterogeneity within communities in order to achieve an accurate understanding of the costs and benefits accruing from the presence of wildlife. All the choice models were estimated with the function "gmnl" in the package "gmnl" (Sarrias and Daziano, 2017) in R version R-3.5.3 (R Core Team, 2019).

To introduce notation, let the utility that individual *n* receives from choosing alternative *i* in choice situation *t* be described by the following linear-in-the-parameters additive random utility function:

$$U_{nit} = \beta X_{nit} + \varepsilon_{nit}$$

Where $\beta$ is a vector of utility weights to be estimated, $X_{nit}$ the levels of our attributes, e.g. number of lions or the presence of bomas, and $\varepsilon_{nit}$ an *i.i.d.* Gumbel distributed error term. Under standard assumptions, the probability that an individual will choose alternative *i* over the other alternatives she is presented with in choice situation *t* can be described by the multinomial logit model (Ben-Akiva et al., 1985, McFadden and Zarembka, 1974):

$$P(i_{nt}|\beta, X_{nit}) = \frac{\exp\,(\beta X_{nit})}{\sum_{j=1}^{J} \exp\,(\beta X_{njt})}$$

Where all terms are as defined above and J denotes the number of available alternatives. While the MNL model is widely used it rests on the assumption of independence from available alternatives and it can only capture observed heterogeneity by interacting socio-demographic variables with the attributes. To overcome these limitations, we use a latent class model (Greene and Hensher, 2003, Train, 2009). In a latent class model, we assume that there exist a finite group of different people in the world whose preferences can be described by a "class" in our model. As such, the LC model

assumes homogeneity within a class but allows for unobserved heterogeneity to exist between classes. As analysts, we do not know which class describes any given respondents' preferences, but we can make probabilistic statements about the likelihood that a class describes an individual's preferences. Let the probability that individual *n*'s preferences can be described by class *q* be denoted by the following (multinomial) probability:$\pi_{nq} = \frac{\exp(\alpha_q + \gamma_q Z_n)}{\sum_{q=1}^{Q} \exp(\alpha_q + \gamma_q Z_n)}$

Where $\alpha_q$ is a class-specific constant, $\gamma_q$ is a vector of class-specific parameters to be estimated and $Z_n$ a vector of individual specific variables, e.g. wealth or fear of lions. Now, we can write the probability that an individual makes a particular sequence of choices as:

$$P(y_n|\beta, \alpha, \gamma, \pi, X_n, Z_n) = \sum_{q=1}^{Q} \pi_{nq} \prod_{t=1}^{T} \frac{\exp(\beta_q X_{nit})}{\sum_{j=1}^{J} \exp(\beta_q X_{njt})}$$

Where $\beta_q$ is a class-specific vector of utility weights. Furthermore, notice that we are now considering the panel structure of the data by taking the product over the sequence of choices made by an individual. Using the parameters of our estimated utility function, we can calculate the sample level WTP as the weighted sum of class-specific WTPs, where WTP is the marginal rate of substitution between the non-monetary and monetary attributes in our estimated utility function.

$$\text{WTP}_n = \sum_{q=1}^{Q} \pi_{nq} \frac{\beta_{q,\text{non-monetary}}}{\beta_{q,\text{monetary}}}$$

To aid with convergence of the latent class models we scaled the compensation attribute by a factor of 100 to ensure that the estimated parameters are of roughly equal magnitude. We split the lions attribute into increase and decrease in lion numbers to capture that increases are disliked, and decreases are liked, and that losses are felt more keenly than gains (Kahneman and Tversky, 1979). To capture the presence of a potential status quo effect (Campbell and Erdem, 2019), we included a

constant for the status quo alternative. In the class probability functions we included the four variables ecocentricity, fear of lions, trust in the compensation scheme and wealth (see Table 1 in for detailed description of the variables and how they were measured). The choice of covariates was based on which variables emerged as important in a comprehensive analysis of attitudes to lions in the Mabale area (Chapter 3) and on our *a priori* hypotheses for explaining variation in preferences towards changes in lion numbers and monetary payments that we observed in the qualitative interviews preceding data collection. Based on the interviews conducted prior to the construction of the choice experiment, we established that there were some people in this area who expressed negative preferences for monetary payments and some who were positive or indifferent to lions. The wealth variable was included to consider that the marginal utility of money varies with wealth (Greene and Baron, 2001). The aspect of ecocentricity evaluated in this study was the belief that components of nature (specifically lions) have an intrinsic right to exist (Washington et al., 2017). Additionally, we included fear of lions in our models, as this emerged as the single most influential explanatory variable of attitude to lions in our previous work (Chapter 3). Fear of lions was measured by the extent to which fear interferes with the daily life of the respondent. Trust in compensation schemes was measured on a scale ranging from 0 (low trust in compensation) to 10 (high trust in compensation) and was included in the models as a continuous variable (Rhemtulla et al., 2012). Our *a priori* hypotheses expected that higher levels of ecocentricity would be associated with higher acceptance of the harms caused by lion presence, and that distrust in compensation schemes would be associated with weaker preferences for compensation payments and would help explain the atypical preferences revealed by some respondents. There were no problematic levels of collinearity (Supplementary materials).

#### 4.3.9. The model development process

We initially used the mixed logit model, to account for random heterogeneity in preferences, (Hensher and Greene, 2003), and the latent class model, which unlike the mixed logit model does

not require assumptions to be made about the distribution of parameters across individuals (Greene and Hensher, 2003), in addition to the simpler MNL model. We began the modelling process by estimating an MNL model, a LC model and a MIXL model without interactions. The sample size did not allow for successful convergence of the MIXL, so we proceeded with the MNL and the LC model. The LC model was run with randomly generated starting values at 1000 iterations, using the Berndt–Hall–Hall–Hausman (BHHH) algorithm to approximate the Hessian matrix, with maximum absolute gradient, numerical tolerance on eigenvalues and relative convergence tolerance level all set to 1e-12. For the LC model, we determined the appropriate class number classes by gradually increasing the number of classes until the BIC started to decrease or until coefficients that are inconsistent with economic theory become apparent.

Subsequently we incorporated covariates as interactions (the interactions we carried out are shown in the results tables). We included four covariates in the models: ecocentricity, fear of lions, trust in compensation schemes and wealth. The choice of covariates was based on which variables emerged as important in a comprehensive analysis of attitudes to lions in this community (Jacobsen et al., 2020) and on our *a priori* hypotheses for explaining variation in attitudes to changes in lion numbers and monetary payments that we observed in the qualitative interviews preceding data collection.

We expect, based on economic theory of the utility of money and on previous studies of the attitudes to lions in the Mabale area (Sibanda et al., 2020), that people will have positive preferences towards monetary payments and negative preferences for increased lion numbers.

4.3.10. Investigating the potential effect of distrust of compensation on value estimatesThe final step in the modelling process to understand the dynamics of valuation in our experiment was to explore the effect of lack of trust in inflating WTA estimates. To our knowledge, the distorting effect of distrust in choice experiments has never before been established, even though this is likely to be an issue in a broad range of contexts, in particular in developing countries (Uslaner, 2018). We

hypothesised that distrust in compensation would lead to a discounting of the monetary compensation attribute in proportion to how likely the respondent perceived it to be that he/she would actually receive the payments in the scenarios described in the choice experiment. In other words, a person gives less weight to monetary payments if he/she does not trust that he/she would receive it, even though it is a hypothetical scenario. Due to the socio-political history of Zimbabwe levels of trust in institutions is low (Mapuva, 2010, Alexander and McGregor, 2000) and past hyperinflation (Kramarenko et al., 2010) events may have reduced trust in the future value of currency. This presents a methodological problem, as choice experiments assume that the participant chooses options as if the outcomes would be real. The bias introduced by the hypothetical nature of the choice experiments has been demonstrated (Hensher, 2010) but we propose that in countries with high levels of corruption and low trust levels, additional bias is introduced through discounting of monetary payments. In order to explore this, we ran the MNL and LC models on subsets of the data with incrementally increasing cut-off threshold for the degree of trust in compensation schemes to see if there was a change in WTA estimates with increasing levels of trust. First, we ran the models with the data from all respondents with trust levels above 0, then all respondents with trust levels above 1, then above 2 and so on. For the LC models, the highest cut-off level was trust scores of 8 and above. Due to the higher number of parameters in the model compared to MNL, the LC model could not reach convergence in the small sample sizes that resulted from running the model on subsets of the data with trust scores above 8.

#### 4.3.11. Calculating total wealth

The wealth of each individual is used in the choice models along with other variables collected in the survey. The amount of wealth an individual possessed in the form of livestock was calculated based on the market value of the livestock the household owned, divided by the number of individuals in the household to derive a per-person figure. The total wealth measures the total annual value of the person's crop production, livestock, formal employment and informal work. The market value of

livestock was obtained from the TKPP Community Survey (2010). Crop production was estimated by asking about the household's production at the last harvest, and the crop prices were established by surveying the markets in the area.

#### 4.3.12. Approach to statistical significance and strength of evidence

Through this thesis I have followed the approach towards statistical significance outlined by Amrhein et al. (2019). It is a statement with more than 800 signatories, which calls for a move away from significance thresholds and towards reporting degrees of strength of evidence. Throughout this thesis I report results according to degree of evidence for an association with the response variable. In the results tables this is indicated with the symbols "." (indicates very low significance level), "*" indicates low level, "**" indicates intermediate level, and "***" indicates high significance level. There is no cut-off level, only degrees of strength of evidence. P-values < 0.1 will be considered evidence that is adequately strong to be worth discussing, as is common in the field of economics (e.g. Goerke and Pannenberg (2015), Schläpfer (2006), Mourato and MacKerron (2010), Bakhshi et al. (2015), Perez Loyola et al. (2021), Armstrong et al. (2019), Fang et al. (2021), Milovanska-Farrington and Farrington (2021), Kumagai (2021), Baldursdottir et al. (2021), Krys et al. (2021), Faccioli et al. (2020), Dardanoni and Guerriero (2021)). To make the strength of evidence clear, the p-value is given not only in the results tables but also as part of the text in the results section. Furthermore, when discussing the variables in the discussion section, the strength of the evidence is mentioned when relevant. Note that the strength of influence of a variable on a model does not relate to p-values but to effect sizes.

## 4.4. RESULTS

### 4.4.1. Model estimates for the MNL model

The results from the MNL model is presented in Table 2, which reveals the preferences towards the attributes presented in the choice experiment. 1481 people living in 593 different households participated in the experiment. Our results showed, as expected, that people have positive preference for compensation payments ($p<0.001$), mobile bomas ($p<0.001$) and guardians ($p<0.001$), and negative preferences for increases in lion numbers ($p<0.001$). The effect of decreases in lion numbers was insignificant. As expected, ecocentricity was associated with less negative preference for increases in lion numbers ($p<0.001$) and fear of lions was associated with more negative preference for increases in lion numbers ($p<0.001$). Furthermore, ecocentricity was also associated with weaker preferences for compensation payments ($p = 0.06$), suggesting a link between value orientations and preferences for monetary compensation measures. There was no evidence of an interaction effect between wealth and preference for lion numbers, but higher wealth ($p<0.001$) and higher levels of trust in compensation ($p<0.001$) were both associated with stronger preferences for compensation (though in the case of the latter, the coefficient is small, at <0.01). Higher levels of trust in compensation was also associated with less negative preferences for increases in lion numbers ($p<0.001$), possibly due to higher confidence in compensation and other conflict-mitigation institutions.

Table 2. Estimate, standard error (SE) and significance level of the multinomial logit model (MNL) model with interaction terms (interactions indicated with "x"). "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001). To aid in interpretation, attributes that occur more than once have been shaded the same colour (light blue for compensation and grey for changes in lion numbers).

| Attribute | Estimate | SE | P-value | * |
|---|---|---|---|---|
| Compensation (attribute levels in US$: 50, 100, 150, 200, 250, 300) | 0.16 | 0.05 | <0.001 | *** |

| | | | | |
|---|---|---|---|---|
| Decrease in lion numbers (attribute levels: 5, 10, 15) | -0.01 | 0.01 | 0.39 | |
| Increase in lion numbers (attribute levels: 20, 25, 30, 35, 40) | -0.04 | <0.001 | <0.001 | *** |
| Mobile bomas (attribute levels: No, Yes) | 0.72 | 0.03 | <0.001 | *** |
| Community guardians (attribute levels: No, Yes) | 0.97 | 0.03 | <0.001 | *** |
| Status quo | -2.01 | 0.09 | <0.001 | *** |
| Increase in lion numbers x ecocentricity | 0.02 | <0.001 | <0.001 | *** |
| Increase in lion numbers x fear of lion | -0.01 | <0.001 | <0.001 | *** |
| Increase in lion numbers x wealth | <0.01 | <0.001 | 0.34 | |
| Increase in lion numbers x trust in compensation | <0.01 | <0.001 | <0.001 | *** |
| Compensation x ecocentricity | -0.08 | 0.04 | 0.06 | . |
| Compensation x wealth | <0.01 | <0.001 | <0.001 | *** |
| Compensation x trust in compensation | 0.02 | <0.001 | <0.001 | *** |

4.4.2. Model estimates for the latent class model

To explore possible unobserved sources of heterogeneity beyond the variables that we included as interactions in the MNL, we use a latent class model. The results are shown in Table 3. People predicted to be in Class 1 prefer compensation ($p<0.001$), mobile bomas ($p<0.001$) and guardians ($p<0.001$) and dislike increases in lion numbers ($p<0.001$), as would be expected to be the typical preferences. This is the largest class accounting for 41% of the sample. Class 2, on the other hand, comprises people who are indifferent to increases or decreases in lion numbers. In line with our hypotheses, we see that people predicted to be in this class are more likely to hold ecocentric values ($p<0.001$) compared to both Class 1 and Class 3, and they are less afraid of lions ($p<0.001$). Class 3, surprisingly, have a negative marginal utility of compensation ($p=0.02$). These people show a high level of distrust in the compensation scheme ($p<0.001$), a point which we discuss in detail below;

hold more ecocentric values ($p<0.001$), albeit less than Class 2; and they have a lower fear of lions compared to Class 1 ($p=0.05$). The preferences of class 3 towards the other attributes were as expected (positive preference towards guardian and bomas, negative preference to increases in lion numbers, and like the other classes, there was no preference towards decreases in lion numbers). The three classes also differ in their strength of negative preference for the status quo, though that does not carry any implications for our investigation of preferences towards lions, guardians, bomas or compensation as the status quo option was identical for all participants.

We hypothesized higher levels of trust in compensation schemes would increase the weight put on the compensation attribute in the choice experiment (and therefore inversely, lower levels of trust reducing the weight put on the compensation attribute). Indeed, our results provide support for this hypothesis.Table 5 shows that the WTP estimates derived when using the dataset that includes all participants are larger than WTP estimated when only running the model on the subset of participants with higher levels of trust with a cut-off level of 8 on the scale of trust in compensation (for more details see 4.3.11.). Here I refer to WTP rather than WTA in order for the values to be comparable to the MNL and the LC model run on the full dataset (table 5). For example, the WTP for lions for class 1 is -US$25 when run on the full data set, and only -US$15 when run on the sub-set of participants with high levels of trust. Figure 2 shows this relationship at different cut-off levels for trust. Further analysis shows that this effect is most pronounced at the extremes of the trust scale (for detailed discussion of this procedure, see section 4.3.11.). As the coefficient of the preference for compensation is used to calculate the economic value of the other attributes (see section on model specification and estimation), this influences the final economic value estimates. It is therefore our contention that more accurate estimates of monetary values are obtained based on the subset of respondents who have high trust in the compensation scheme (on the Likert scale this refers to levels 8-10). We remark that direct comparisons of the models are inappropriate, but from

Table 5, we see that we obtain qualitatively the same results. However, estimates of value are up to 40% smaller, when we only consider people who have trust in the scheme[2].

Table 3. Estimate, standard error (SE) and significance level of the latent class model (LC) with interaction terms. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| | Class 1 | | | | Class 2 | | | | Class 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Est. | SE | P-value | * | Est. | SE | P-value | * | Est. | SE | P-value | * |
| **Utility function** | | | | | | | | | | | | |
| Compensation (attribute levels, US$: 50, 100, 150, 200, 250, 300) | 0.23 | 0.04 | <0.001 | *** | 0.62 | 0.05 | <0.001 | *** | -0.17 | 0.08 | 0.02 | * |

[2] Plotting the size of the coefficients at different cut-off levels show that this trend in WTA is driven by increasing coefficients for the cost attribute, showing that the preference for compensation becomes higher at higher levels of trust in actually receiving the compensation in the choice scenario (Figure 2, S1 and S2)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Decrease in lion numbers (attribute levels: 5, 10, 15) | -0.01 | 0.02 | 0.65 | | <0.001 | 0.02 | 0.88 | | -0.02 | 0.02 | 0.37 | |
| Increase in lion numbers (attribute levels: 20, 25, 30, 35, 40) | -0.06 | <0.001 | <0.001 | *** | <0.001 | <0.001 | 0.59 | | -0.07 | 0.01 | <0.001 | *** |
| Mobile bomas (attribute levels: No, Yes) | 1.22 | 0.07 | <0.001 | *** | 0.63 | 0.08 | <0.001 | *** | 0.43 | 0.13 | <0.001 | *** |
| Community guardians (attribute levels: No, Yes) | 0.7 | 0.07 | <0.001 | *** | 1.5 | 0.1 | <0.001 | *** | 2.41 | 0.21 | <0.001 | *** |
| Status quo | -3.58 | 0.31 | <0.001 | *** | -2.59 | 0.29 | <0.001 | *** | -1.38 | 0.24 | <0.001 | *** |
| Interactions with class probability | | | | | | | | | | | | |
| Ecocentricity | NA | NA | NA | NA | 0.84 | 0.23 | <0.001 | *** | 0.49 | 0.27 | <0.001 | *** |
| Fear of lions | NA | NA | NA | NA | -0.56 | 0.2 | <0.001 | *** | -0.21 | 0.26 | 0.05 | . |
| Trust in compensation | NA | NA | NA | NA | 0.09 | 0.02 | <0.001 | *** | -0.03 | 0.03 | <0.001 | ** |
| Wealth | NA | NA | NA | NA | 0.01 | <0.01 | <0.001 | *** | 0 | 0.01 | 0.64 | |
| **Class probability function** | | | | | | | | | | | | |
| Constant | NA | NA | NA | NA | -1.51 | 0.32 | <0.001 | *** | -1.19 | 0.38 | <0.01 | ** |
| **Average class probability** | 0.41 | 0.02 | | | 0.22 | 0.01 | | | 0.37 | 0.01 | | |
| LL | -5401.75 | | | | | | | | | | | |
| BIC | 11056.53 | | | | | | | | | | | |
| N | 8410 | | | | | | | | | | | |
| K | 28 | | | | | | | | | | | |

Table 4. Estimate, standard error (SE) and significance level of the latent class model (LC) with interaction terms run on the sub-sample of data with high levels of trust in compensation. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| | Class 1 | | | | Class 2 | | | | Class 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimate | SE | P-value | * | Estimate. | SE | P-value | * | Estimate | SE | P-value | * |
| **Utility function** | | | | | | | | | | | | |
| Compensation (attribute levels, US$: 50, 100, | 0.38 | 0.07 | <0.001 | *** | 0.77 | 0.09 | <0.001 | *** | -0.03 | 0.14 | 0.05 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150, 200, 250, 300) | | | | | | | | | | | | |
| Decrease in lion numbers (attribute levels: 5, 10, 15) | 0.01 | 0.03 | 0.48 | | -0.01 | 0.03 | 0.87 | | -0.03 | 0.04 | 0.56 | |
| Increase in lion numbers (attribute levels: 20, 25, 30, 35, 40) | -0.06 | 0.01 | <0.001 | *** | 0.01 | 0.01 | 0.26 | | -0.08 | 0.01 | <0.001 | *** |
| Mobile bomas (attribute levels: No, Yes) | 1.34 | 0.14 | <0.001 | *** | 0.78 | 0.12 | <0.001 | *** | 0.51 | 0.17 | 0.21 | *** |
| Community guardians (attribute levels: No, Yes) | 0.19 | 0.14 | <0.001 | *** | 1.64 | 0.16 | <0.001 | *** | 3.08 | 0.28 | <0.001 | *** |
| Status quo | -2.83 | 0.43 | <0.001 | *** | -2.97 | 0.61 | <0.001 | *** | -2.16 | 0.38 | <0.001 | *** |
| Interactions with class probability | | | | | | | | | | | | |
| Ecocentricity | NA | NA | | NA | 1 | 0.35 | <0.01 | * | 1.1 | 0.48 | <0.01 | ** |
| Fear of lions | NA | NA | | NA | -0.61 | 0.3 | <0.001 | *** | -0.03 | 0.38 | <0.001 | *** |
| Trust in compensation | NA | NA | | NA | 0.32 | 0.19 | <0.001 | *** | 0.05 | 0.21 | 0.9 | |
| Wealth | NA | NA | | NA | 0.01 | 0.01 | 0.06 | . | -0.01 | 0.01 | <0.001 | *** |
| **Class probability function** | | | | | | | | | | | | |
| Constant | NA | NA | | NA | -4.14 | 2.11 | 0.05 | * | -1.79 | 2.24 | <0.01 | ** |
| **Average class probability** | 0.56 | 0.09 | | | 0.18 | 0.03 | | | 0.25 | 0.08 | | |
| LL | -1908.16 | | | | | | | | | | | |
| Adj. R sqr. | 0.43 | | | | | | | | | | | |
| BIC | 4041.368 | | | | | | | | | | | |
| N | 3094 | | | | | | | | | | | |

| K | 28 | | |
|---|---|---|---|

### 4.4.3. Willingness to pay for the marginal lion and WTP for mobile bomas and community guardians

Of perhaps greatest interest to policy makers are the estimates of willingness-to-pay (WTP) and willingness-to-accept (WTA). In Table 5, we show how these value estimates change with increasing levels of complexity. WTA is the equivalent of negative WTP, and the choice of metric used to present the results will depend on which allows the most intuitive interpretation. The choice of WTA versus WTP in the calculation of value and the presentation of results is a separate issue from the choice of whether to use WTA versus WTP on the choice cards. Econometrically they are equivalent, and the choice of WTA versus WTP on the choice cards was based on the perceived acceptability of the two metrics among the participants. When presenting the results, WTA will only be used when estimating the effect of trust level on value in section 4.4.5, otherwise WTP will be used)

Using the simplest model, WTP for each additional lion is -US$26 per month (Table 5). This means that people perceive lions to have a value that is equivalent to negative US$26 per lion per month. In the latent class model (which incorporates heterogeneity between groups) people predicted to be in Class 1 are willing to pay -US$15 per lion per month. This means that for that grouping of people, lions have a value that is equivalent to negative US$15 per lion per month. WTP is undefined in Class 2 because the parameter for increases in lions is insignificant and Class 3 has a negative preference for compensation. As discussed in section 4.4.2., the value estimates from the latent class model using the high-trust segment of the dataset are likely to give the most accurate value estimates, so those are the figures that will be discussed throughout. People predicted to be in Class 1 were willing to pay US$350 and US$50 per month for mobile bomas and community guardians respectively. People predicted to be in Class 2, on the other hand, were willing to pay US$101 for mobile bomas and US$212 for community guardians. In other words, people in this area attach high

value to the mobile bomas and community guardians, though the grouping described as Class 1 values the mobile bomas more highly, while the grouping described as class 3 values the community guardians more highly.

Table 5. Estimates of willingness-to-pay (WTP) per month (US dollars) from multinomial logit (MNL) and latent class (LC) models

| Model | WTP for the marginal lion | WTP for mobile boma protection | WTP for community guardian protection |
|---|---|---|---|
| MNL model | -US$26 | US$460 | US$622 |
| Latent class model – Class 1 | -US$25 | US$531 | US$305 |
| Latent class model – Class 2 | NA | US$103 | US$243 |
| Latent class model (high trust) – Class 1 | -US$15 | US$350 | US$50 |
| Latent class model (high trust) – Class 2 | NA | US$101 | US$212 |

### 4.4.4. Measuring WTP in terms of biodiversity outcomes

Valuation estimates are usually estimated with monetary units as currency, or with other forms of payment, such as food rations, school supplies or labour hours. We would argue that when changes in a biodiversity metric or conservation outcome is the objective of the valuation, calculating WTP in terms of the desired change in the biodiversity is perhaps even more informative. In the context of lion conservation in Hwange area, increases in lion numbers constitute a cost to most inhabitants, while mobile bomas and community guardians constitute goods provided to people by the conservation organisation operating in the area (TKPP). The project provides mobile bomas and community guardians as a strategy to induce higher tolerance of lions. It is therefore as informative, to calculate WTP with the number of lions as currency instead of WTP in dollars. Substituting the coefficient for compensation with the coefficient for increase in lion numbers in the WTP equation allows the estimation of the WTP for mobile bomas and community guardians. Using the LC model

with interactions on the full data set (there is no need for using the high trust data set as we no longer use the compensation coefficient) gives WTP estimates of 12 lions for community guardians and 22 for mobile bomas in the case of class 1, and 35 lions for community guardians and 6 lions for mobile bomas in the case of class 3. This means that, for example, the people who are grouped within class 1 are willing to accept living alongside an additional 12 lions if they are provided with community guardians. Class 2 does not have a significant preference for changes in lion numbers, so WTP in lion terms is not meaningful for that class.

#### 4.4.5. Exploring distrust of compensation as a source of bias in WTA estimates

We found that running the LC model on increasingly high cut-off levels for trust in compensation lead to decreasing value estimates at the extremes of the distribution. Higher levels of trust in compensation leads people to demand lower values per additional lion. This may possibly be because they have higher degree of trust in receiving the compensation, and they therefore discount the payments to a lower degree.

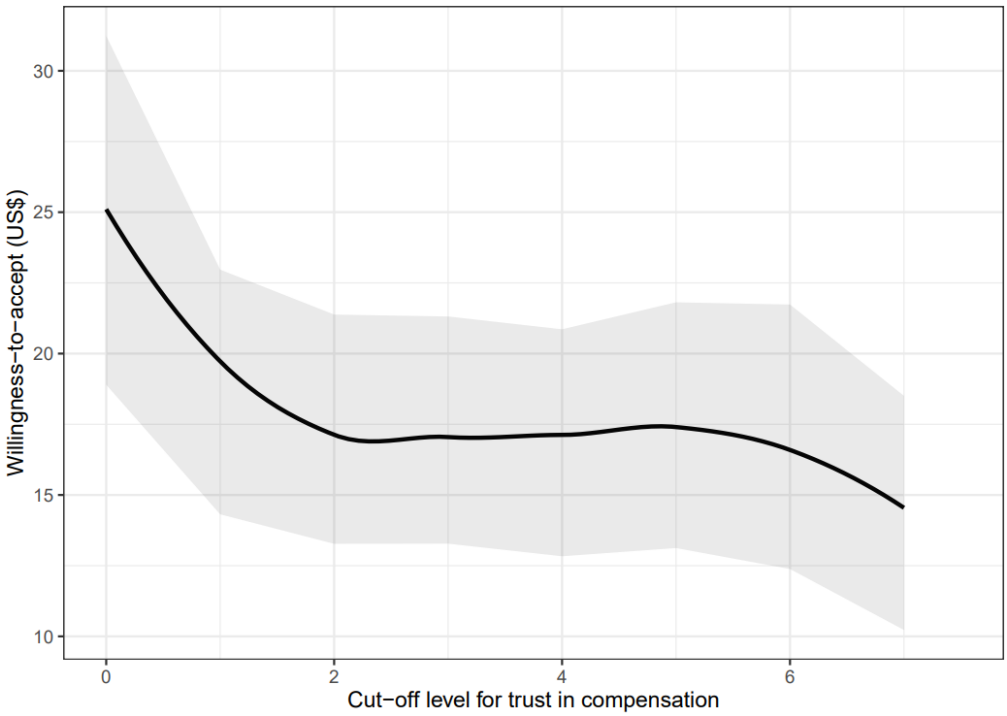



Figure 2. WTA (in US dollars) for increases in lion numbers estimates from the LC model with interaction terms (class 1) at increasing cut-off levels of trust (maximum cut-off level 7). 95% confidence interval in grey.

## 4.5. DISCUSSION

### 4.5.1. Preferences for changes in the lion population

The estimates of WTP for increases in lion numbers need to be interpreted in the context of wealth and livestock losses. The average wealth of the participants in this choice experiment was US$1050 per annumIn this area the average market price is US$297 for a cow, US$346 for an ox, US$135 for a donkey and US$40 for a goat (TKPP Community Survey 2010). Even the highest WTP estimate of -US$26 monthly (i.e. -US$312 annually) for the marginal lion does not seem disproportionate if you expect to lose an additional cow per additional lion in your local area (Table 5). A WTP estimate of -US$26 monthly per lion means that the person would have to be compensated US$26 monthly to be as satisfied with having an additional lion in the area as they would be without the additional lion. The average loss of livestock value in terms of market value is only US$3.29 annually per household in the Mabale area, however, losses are heterogeneously distributed. The maximum loss recorded

by the TKPP in a single incident through in the time covered in their records (2008 – 2020) was US$1484 in terms of market value of the livestock lost. So all the estimates fall within the range of possible losses. However, for the average participant, the disvalue of lions is higher than the average loss in terms of market value of livestock. Economic theory expects costs to be assessed in averages, as this weighs the costs of the event by probability of the event occurring. Expected utility theory posits that if the expected benefit of an action exceeds the expected cost, then the action will be beneficial to the individual decision maker (Mongin, 1998). However, this is a simplified approach to individual decision-making that frequently does not correspond to individual psychology (Starmer, 2000). Respondents may in reality be thinking in terms of possible losses rather than likely losses. For example, they might be estimating value based on scenarios where they lose cattle (in which case they will lose US$297 or more) and assign only a low weight to the probability of that event actually occurring to them. Furthermore, average loss of livestock value in terms of market value is only US$3.29 annually per household is the measure of objective financial risk, while people are operating only with perceived risk, and the perceived risk of lion predation may be significantly higher which may also contribute to explaining why the value estimate (up to US$26 monthly, depending on model used for the estimation) is higher than the expected loss (US$3.29). If assuming that respondents weigh the costs of loss by the probability of loss and that they have a reasonably accurate perception of the risk of lion predation based on their experiences living in the area, this discrepancy reveals the magnitude of the intangible costs of living alongside lions - the total disvalue is much higher than the market value of livestock lost. This is the cost of fear, stress, opportunity costs and the cost of time spent in loss-prevention behaviours. The human-wildlife conflict field has come to recognise that intangible costs are strong drivers of conflict (Barua et al., 2013) but this is the first estimate showing the magnitude of the discrepancy between total costs of living alongside lions and the market value of livestock lost. However, we do not know how people in the area think about potential losses or how close their risk perception is to the objective risk, and it cannot be assumed that people operate according to economic theory, so this is only a tentative finding in the

light of the absence of information about the cognitive processes that participants used to estimate the value of an additional lion in the choice experiment.

Depredation on livestock by lions may not simply be a linear product of lion numbers as social dynamics within the pride, dispersal events and individual behavioural differences affect the rate of predation of livestock (Loveridge et al., 2017b). If making the simplifying assumption that the average annual losses of livestock to lion predation (US$3.29 per household) increases in proportion with average lion numbers in the area (16 lions), we expect the marginal lion to increase depredation rates by US$0.20 per household in terms of the market value of livestock. Our estimate of WTP from the high trust LC model (-US$180 annually) is 817 times larger per lion. That means that the negative value that people perceive as arising from the presence of a lion is 817 times larger than the average market value of livestock lost to predation. If assuming that respondents weight costs by the likelihood of those costs occurring and that they have an reasonably accurate perception of the risk of lion predation (two simplifying assumptions that we do not know whether holds in this study system), then this highly simplified and stylised representation gives us a notion of the scale of the possible discrepancy between material and intangible costs for the people living alongside the lions. This discrepancy of US$167.8 of costs may contain a wide range of non-material costs and harms (defence measures do not typically entail monetary costs as fencing material for traditional cattle enclosures are constructed from free materials and herding is provided by younger family members or by pooling livestock herds). Results from analysis of the attitudes of these respondents towards coexisting with lions (Chapter 3) showed that the variable with the largest effect size was the degree to which fear interfered with their daily lives. This effect was even larger than the effect of livestock loss. The importance of fear as an intangible cost of lion presence is supported by the interaction terms of our choice models.Increased levels of fear makes the disutility of increases in lion numbers slightly larger in the MNL model (the coefficient is only -0.01), and substantially reduces the chance of belonging to the class without a negative preference towards

lion numbers in the LC model with a coefficient of -0.56. There was very strong evidence for an association as $p<0.001$ in both cases. The total cost of lion presence is clearly much larger than the value of livestock lost to predation. Fear is also linked to compensation sensitivity as there is weak evidence ($p<0.01$) that people who are more afraid of lions are less likely to forego compensation payments.

It is also important to keep in mind that, though it is a very rare occurrence, lions present a potential risk to human life, so we expect high negative WTP for increases in lion numbers. In other words, we expect that one would have to compensate people high amounts of money to balance the increased costs and risks that people perceive as arising from the presence of a lion. 856 of 1481 respondents personally knew someone who had been attacked by a lion. This number is large because the interconnectedness of these communities means that many people know the same individuals. There has only been one death between 2000-2018 (a child), but there have also been attacks prior to this time period (one older man showed us scars from lion claws when we interviewed him). Valuation of attributes that reduce/increase the risk of death, such as the community guardians, are frequently very high. Methods for valuation of a statistical life frequently find values of millions of dollars (Jongejan et al., 2005) so the values derived here for the attributes that relate to the risk of death due to lions are not necessarily implausible.

Lion presence does also entail some benefits. Respondents cited valuing lions due to their position in traditional religious beliefs, bequest value for their children, and for income related to tourism and trophy hunting. However, only 31% of participants perceived there to be any benefits of lion presence, and the WTP estimates show that any such benefits are outbalanced by perceived costs, giving a net negative value of lions.

The LC model with interaction terms confirmed our hypothesis that people with more ecocentric value-orientations are less likely to hold negative preferences to lions (at a high significance level of

<0.001). Interestingly, there is strong evidence (<0.001) that ecocentricity also increases the chance of having a negative preference towards compensation payments (though to a lesser degree). The results from the MNL model lends further support: the interaction between the compensation attribute and ecocentricity is negative, showing the ecocentric people have a weaker preference for compensation payments. However, this evidence for this interaction is weak (p= 0.06). There is strong evidence (<0.001) that people with higher levels of trust in compensation are less likely to have a negative preference towards lions.

4.5.2. Preferences for mobile bomas and community guardians

The results from the most complex model (the LC model run on the high trust subsample) estimates WTP to be US$350 per month for mobile bomas and US$50 per month for community guardians in the case of class 1 (consisting of people who prefer compensation, mobile bomas and guardians and dislike increases in lion numbers), and US$101 for mobile bomas and US$212 for community guardians in the case of class 2 (comprised of people who have a positive preference towards compensation but are indifferent to increases or decreases in lion numbers). This means that people in the area attach a high value to these two services. However, the WTP estimates for mobile bomas and community guardians are very high relative to the average wealth of the area. Several factors might be contributing to this. There might be some strategic behaviour to signal the desirability of the conflict-mitigation programmes. Though I have not been able to find any evidence of exaggeration occurring in order to encourage the continuation of a conflict-mitigation scheme, there are situations where authors suspect that livestock losses are exaggerated in the hope for compensation (Namgail et al., 2007, Aryal et al., 2014).Economic theory and past empirical investigations also lead us to expect high values from this experiment. Firstly, framing the cost attribute as WTA rather than WTP typically leads to higher estimates as the respondent is released from budget constraints. However, WTA was the only possible elicitation format. Secondly, prospect theory predicts that losses are given greater weight than gains, leading us to expect higher estimates

from when using WTA as an elicitation format than from WTP (Plott and Zeiler, 2005). Additionally, the majority of participants are taking part in either the mobile boma or community guardian programme, or both. This endowment effect (Kahneman et al., 1991, Thaler, 1980) leads us to expect WTA to be high to avoid the loss of services they are currently benefiting from. Third, community guardians attempt to keep lions and other predators away from the villages and thereby may also be perceived to reduce the risk of death, which, as discussed in relation to the WTA estimates for increases in the lion population, is expected to yield very high estimates. This effect may also apply to the mobile bomas, as this highly effective livestock enclosure reduces the necessity of dangerous confrontations with predators during the night, which is among the most common situations that lead to human injuries (Loveridge*, personal communication*). Fourth, both bomas and guardians create value beyond preventing harm from lions. Community guardians also ward off other species of predators, such as spotted hyaenas, and mobile bomas dramatically improve maize yields through fertilisation which participants cite as equally important to the protection of livestock (Loveridge and Hunt, 2016). As the boma is mobile, it can be moved periodically and crops can be planted in the nutrient rich soil that remains. Though the estimates of the economic value of the mobile bomas and community guardians are still likely to be exaggerated, the relative size of the two attributes is informative. The predominant class (class 1) value mobile bomas much higher than community guardians. However the analysis also reveals that diverging preferences exist in the population with stronger preferences for community guardians among the remainder of the population. Class 2 attaches roughly twice as high value to community guardians than class 1, and examining the coefficients of Class 3 shows a preference for community guardians that is five times higher than the preference for mobile bomas.

### 4.5.3. The effect of distrust of compensation on monetary WTA estimates

Our results shows that distrust towards compensation schemes can exert powerful influence on WTA estimates (Figure 2, S1 and S2). In the most comprehensive LC model, which incorporates

interaction terms and only high-trust respondents, accounting for lack of trust in the compensation vehicle drastically reduces estimated WTA for the marginal lion, mobile bomas and community guardians (Table 5) and yields much more realistic value estimates. In other words, distrust in compensation can distort the analysis in such a way that the value (whether negative or positive value) that people place on lions (or anything else that is being valued) becomes exaggerated. This is something which the economic valuation field must either control for econometrically or acknowledge as a likely source of inflation of WTA estimates in contexts of low trust. Lower trust in institutions, particularly related to the distribution of money, is common in developing countries, while the majority of choice experiment research has been carried out in developed countries (Kim, 2010).

#### 4.5.4. WTP in terms of lion numbers

Conservation programmes that revolve around providing benefits to local communities in order to improve pro-conservation attitudes and behaviours have the objective of improving biodiversity outcomes, so providing WTP in a biodiversity metric could be more directly interpretable. We calculated WTP for the two conflict mitigation programmes of the TKPP with increases in the lion population as the currency of payment (see section 4.4.2. in Results). The estimated WTP for mobile bomas was 22 lions and 6 lions for class 1 and 3 respectively, and the WTP for community guardians was 12 lions and 35 lions for class 1 and 3 respectively. That means that people in class 1 would be willing to accept 22 lions if they were provided with mobile bomas, and people in class 3 would be willing to accept 6 lions. People in class 1 would be willing to accept 12 lions if they were provided with community guardians, and people in class 3 would be willing to accept 35 lions. These figures all fall close to the realistic range of lion populations in this area, which is estimated to have a maximum carrying capacity of approximately 40 lions. However, the coefficients are likely to suffer from some inflation as discussed in the above section on WTP for mobile bomas and community guardians. Still, this provides a demonstration of the use of a biodiversity outcome as a WTP metric, and we

recommend wider use of this approach in economic valuation studies as it avoids the difficulties posed by lack of trust in compensation institutions and presents WTP in the metric that is actually outcome of interest for conservation policy.

### 4.5.5. Management implications

The economic value of lions that we estimate in terms of WTP shows that the costs perceived by the people who live alongside these apex predators are hundreds of times larger than the market value of the livestock that is lost to predation by lions when assessed according to simplifying economic assumptions (though the real discrepancy cannot be established without further knowledge of the cognitive processes used to relate cost to probability, and of the magnitude of perceived risk as opposed to objective risk). Under these assumptions, a narrow focus on material losses that has characterised the human-wildlife conflict field for much of its history seemsinadequate and severely underestimates the magnitude of harms experienced by local stakeholders. Intangible costs can be very large. Conflict mitigation strategies that operate with a fractional notion of the costs perceived by local communities are unlikely to provide enough benefits of wildlife presence for the communities to see the maintenance of wildlife populations as a desirable objective. Conservation is an uphill struggle if the incentives of the closest stakeholders are not aligned with the conservation objectives (Madden, 2004).

This disvalue of the marginal lion provides a useful figure for illustrating the shortfall in transfer of benefits from members of the global public that benefit from the existence value of lions to the people who bear the brunt of the costs of maintaining lion populations. The figure of -US$180 per person annually in the local communities would provide the figure to be used in a mechanism for transfer of benefits from the global public to local stakeholders to equalize externalities. Though impossible in practice for a wide variety of reasons, this can provide a wake-up call for the increased need for investment in maintaining global biodiversity goods, such as the existence of lions.

Our LC models show the importance of disaggregating heterogeneity in preferences when designing conservation actions. Within the communities of the Hwange National Park area, we found sub-groups that differ from the basic assumption that people are negative to lion presence; one group did not perceive any significant costs of lion presence. Even monetary payments cannot be assumed to be universally popular: one group displayed a negative preference to monetary compensation payments, citing religious beliefs, social and safety concerns. However, the strength of evidence was on the weak side of the range of acceptable evidence ($p=0.02$), which could either be due to Type I error (Agresti and Finlay, 2009) or due to this preference being only a mild preference. Alternative incentives for coexistence would be necessary for the latter group to promote coexistence with lions. Both mobile bomas and community guardians are highly valued, though our estimates are not sufficiently precise to provide an exact economic value. However, it is clear that different sub-groups value the two programmes to different degrees, with community guardians coming up with the highest overall value when treating all participants together in the MNL model. The results show that people who are more fearful of lions have stronger negative preferences for increases in the lion population, with a strong degree of evidence ($<0.001$). Wildlife management agencies and conservation organisations can enact programmes aimed to reduce the need to be fearful of lions in order to mitigate the costs that people perceive and thereby reduce the negativity of preferences. We also found strong evidence ($<0.001$) that higher levels of wealth to be associated with less negative preferences towards changes in lion numbers in the LC model, indicating that wealth provides a buffer from the negative effects of lion presence. This has implications for prioritisation of conservation resources, necessitating focus on the less wealthy households. However, causality is not certain, as there is the possibility that fear and wealth are connected to some latent variables, such as the fear of livestock loss, with causal relationships to perceived cost.

### 4.5.6. Limitations of the results

There are a few limitations to the analysis presented here. First, incorporating attitudinal variables directly in the utility function or class probability function may introduce endogeneity bias (Hess and Beharry-Borg, 2012). To assess whether endogeneity bias was likely to be present, we first ran the models without and then with the interaction terms in the MNL model and covariates in the class probability function in the latent class model. There was no marked difference in the signs, significance or relative magnitude of the coefficients, which indicates that if present, the bias is small. Furthermore, we ran linear regression models using the individual specific class probabilities as the response variable, and the attitudinal variables as explanatory variables. The relationships between attitudinal variables and the individual class probabilities were similar to those observed in the LC model, providing further evidence that endogeneity bias may not be a large concern in this particular dataset. Two terms (the interaction between trust in compensation and ecocentricty in the MNL model and the interaction between trust in compensation and fear of lions in the LC model) where only significant at a threshold of $p<0.1$. This is relatively weak evidence and there is therefore a risk of type I error and therefore a false positive.

## 4.6. CONCLUSION

The total economic value of the marginal lion for a member of the communities that live alongside them is estimated to be -US$180 annually. This total per person costs is roughly 817 times larger than the monetary value of the livestock expected to be lost annually per additional lion per household. Though the estimate of average expected predation by the marginal lion is only a stylised representation of predation dynamics, this shows that the value of the material losses, which has been the only quantitative data available for compensation schemes and conservation actions so far (as evidenced by lack of any publications on compensation schemes using other quantitative data than materials losses as the basis for compensation amounts), vastly underestimates the total costs

experienced by the communities that live closes to predator populations. These costs likely include fear, stress, costs of avoidance behaviours and threat to human life. Our findings have relevance for a wide range of situations where people and potentially dangerous species of wildlife co-exist. The large value of the harm perceived by local communities that is revealed when including intangible costs may contribute to explaining why compensation schemes and community-based natural resource management initiatives are often unsuccessful (Dressler et al., 2010) and why human-wildlife conflict has proven such a difficult issue to solve or mitigate. It would be very challenging to generate sufficient benefits to offset harms of such a magnitude. This challenge appears particularly stark when considering that the figure of -US$180 per person annually is only the impact of a single lion. People who live near protected areas often have to contend with several wildlife species that impact livelihoods and personal safety (Treves, 2009). For example in Africa, lions, leopards, hyaenas and elephants, which can cause considerable human-wildlife conflict, often co-occur (Goldman et al., 2010, Kaltenborn et al., 2006).

Comparing the large costs experienced by people living alongside lions with the strong expressions of international support for lion conservation (Macdonald et al., 2016) reveals the enormous discrepancy between the global value of lions and the local costs of lion presence.

**Statement of Authorship for joint/multi-authored papers for PGR thesis**

To appear at the end of each thesis chapter submitted as an article/paper

| | |
|---|---|
| Title of Paper | What is a lion worth – quantifying of the costs of living alongside a top predator |
| Publication Status | □Published □ Accepted for Publication<br>□Submitted for Publication □ **x** Unpublished and unsubmitted work written in a manuscript style |

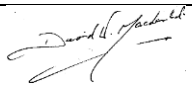
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| Publication Details | |

## Student Confirmation

| | | | |
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| Student Name: | | | |
| Contribution to the Paper | I lead a team of research assistants to carry out data collection. Performed the analysis and wrote the manuscript.<br><br>I adapted R code written by Erlend Dancke Sandorf.<br><br>Davide Contu designed the D-efficient choice cards by using N-gene software.<br><br>The remaining co-authors contributed with advice on methodology and strategy, facilitated fieldwork, and commented on the paper through its development. | | |
|  | | Date | 6th September 2020 |

## Supervisor Confirmation

By signing the Statement of Authorship, you are certifying that the candidate made a substantial contribution to the publication, and that the description described above is accurate.

| | | |
|---|---|---|
| Supervisor name and title: Prof David Macdonald | | |
| Supervisor comments: Mr Jacobsen brought great originality and an enormous effort to this work, and led an expert team. His contribution was predominant and overwhelming. | | |
| Signature  | Date | 25/9/20 |

# CHAPTER 5. Happiness and lions – the impact of living alongside lions on wellbeing

## 5.1. ABSTRACT

Potentially dangerous megafauna can affect the wellbeing of the people living alongside them though impact on their livelihoods and personal safety (Barua et al., 2013). Using the life satisfaction method, we demonstrate that experiencing livestock loss to lions is linked to detectable negative impact on the happiness (wellbeing) of the people who live alongside these top predators. The total economic value of this harm (which includes every aspect of harm, from the value of predated livestock to emotional harm caused by fear and stress) was estimated to be equivalent to US$5800 annually per person in agro-pastoral communities in Zimbabwe using ordinal logistic regression models. Conservation initiatives that aim to mitigate the impact of lions by using monetary compensation or financial development programs will rarely have access to the necessary funds. Education and health also had appreciable effects on wellbeing, suggesting that providing education and health services could be more cost-effective mitigation methods if purely interested in off-setting the negative effects on wellbeing of carnivore presence.

Fear of lions was also associated with lower wellbeing, and the magnitude of the effect was similar to that associated with livestock loss. The national park also had some positive impacts on happiness; people who perceived receiving more benefit from the national park reported higher wellbeing. However, the majority of participants perceived no benefits arising from the national park. Improved transfer of benefits from the national park provides another promising avenue for off-setting the negative impact of lion presence on wellbeing.

## 5.2. INTRODUCTION

Living alongside large carnivores often impacts the lives of the communities living alongside them, both in beneficial and detrimental ways. Large carnivores can bring tourism revenue and employment (Ghosh and Uddhammar, 2013), but they can also inflict serious costs, such as depredation of livestock or even pose a threat to human life (Packer et al., 2019). The material costs are well known and have often been quantified, but what about the impact on people's happiness? Arguably, people aim to maximise their wellbeing (commonly referred to as happiness) (Deci and Ryan, 2000) and pursue economic, social and personal development (or carnivore eradication) in order to improve their wellbeing. We argue that it is therefore valuable to study wellbeing directly in order to estimate the impact of living alongside large carnivores, and not just indirectly through the factors that influence wellbeing, such as wealth, access to resources, personal safety and so on. Wellbeing may be more accurate predictors of attitudes towards wildlife because people consider a wider range of complex factors when deciding how they feel about wildlife than researchers can realistically hope to capture. Self-reported subjective wellbeing provides insight into the myriad of aspects of life that shapes a person's view on wildlife (Dolan et al., 2011). Therefore, we chose to investigate the relationship between risks from lions (both perceived and real risk levels) and the wellbeing of communities living alongside them. We also investigate how wellbeing is influenced by demographic, social and economic factors, as well as people's perceptions and past experiences with wildlife.

The study of wellbeing, sometimes referred to as the "science of happiness", aims to not only measure wellbeing, but also to identify the factors that affect it and quantify their relative importance (Ballas and Tranmer, 2012). This has been applied to a range of situations in developing countries, such to study poverty, cultural constructions of wellbeing (Camfield et al., 2009) and the impact of education on wellbeing (Webb, 2009). The impact on subjective wellbeing of living

alongside carnivores has not been quantified despite the potential of powerful predators to influence the communities that co-inhabit the same space.

Conservationists are concerned with human wellbeing for both pragmatic and ethical reasons (Woodhouse et al., 2015). Among the motivations is to gain legitimacy in the eyes of local stakeholders as conservation outcomes are often more successful if people's views and needs are taken into account, and because improving outcomes for people is often a goal alongside biodiversity goals (Milner‐Gulland et al., 2014). This is part of an effort to move beyond narrow monetised approaches to assessing the impact of conservation on communities. There are also ethical implications when conservation actions impact people who are poor, vulnerable or disempowered (Milner‐Gulland et al., 2014), such as the Zimbabwean communities that are the focus of this study.

The concept of wellbeing is multidimensional, and can be constructed to encompass all aspects of human lives, from satisfaction with material circumstances to fulfilment through social interactions and family life (Bandura, 1999). Beauchamp et al. (2018) point out that despite the popularity of the term "wellbeing", it is rarely defined or examined empirically in the conservation field. We present an empirical examination of wellbeing in relation to the presence of a large carnivore, with a quantitative measure of subjective wellbeing as the chosen metric: self-assessed life satisfaction. There are three commonly used concepts of wellbeing within the field of subjective wellbeing economics. The first is hedonic wellbeing, which relates to the ongoing experience of wellbeing. The hedonic approach aims to measure the balance of pleasurable and unpleasant feelings in an individual's life (Bruni, 2007). Surveys based on hedonic notions of wellbeing typically ask participants how happy they have been feeling within a defined time-span, however, innovative approaches that make use of smartphone technology have mapped moment-by-moment experience of hedonic wellbeing (MacKerron and Mourato, 2013). The hedonic approach is based on the

assumption that individuals aim to maximise the experience of pleasure and minimise the experience of unpleasurable feelings (Henderson and Knight, 2012). In contrast, the eudaimonic approach is based on wellbeing being contingent on 'flourishing', purpose and meaning in life, and the realization of the individual's potential (Ryan and Deci, 2001). The third approach is referred to as evaluative wellbeing or self-assessed life satisfaction, where people are asked for global assessments of their lives. In other words, how satisfied are they with life as a whole (Steptoe et al., 2015). The evaluative life satisfaction approach combines elements of hedonic and eudaimonic notions of wellbeing. The subjective life satisfaction approach asserts the centrality of the individual and is based on the belief that the individual rather than the researchers is the best judge of own wellbeing, thereby reducing disciplinary and cultural biases (Agarwala et al., 2014, Kaiser, 2020, Rojas, 2007). Socio-cultural contexts evolve continuously and therefore also people's conception of wellbeing. The life satisfaction approach does not rely on fixed indicators of wellbeing (such as access to particular services or goods) and therefore allows for change in what is considered components of wellbeing as well as changes in the relative importance of these components (Agarwala et al., 2014).

Life satisfaction ratings can be used to calculate economic value when combined with explanatory variables in regression models by calculating the marginal rate of substitution between the monetary variable and the variable that is to be valued (Ferreira and Moro, 2010). This marginal rate of substitution represents the level at which income and the variable of interest can be traded-off and leave people on average equally happy. For example, in a study of the trade-off between income and air quality, a 1 µg/m3 reduction in PM10 was found to increase life satisfaction to an equivalent degree as earning US$459 more per year (Levinson, 2012). We present the first economic valuation estimate for a carnivore using the life satisfaction method.

## 5.3. METHODS

### 5.3.1. Study site:

The study site was the Mabale area of Hwange Communal Land on the north border of Hwange National Park, a large protected area which is home to several species of large carnivore, including lions (*Panthera leo*). Subsistence agro-pastoral activities is the main livelihood strategy (Loveridge et al., 2017a). The largest ethnic groups are Ndebele, Nambya and Tonga peoples. Lions that venture onto village land pose a threat to livestock and are vulnerable to being injured or killed by people (Loveridge et al., 2017b). The Trans-Kalahari Predator Project (TKPP) runs conflict mitigation projects in the area, aimed at facilitating coexistence of people and large carnivores as lions pose a threat to livestock and people's safety, and people sometimes persecute lions (using both legal and illegal means). The community guardian programme employs local men and women to work with the local communities to improve livestock protection, and they also chase lions back into the protected area if they stray into village lands – both for the protection of the people and the lions. The project also provide mobile cattle enclosures (called mobile bomas) for livestock protection during the night. The mobile bomas are constructed from PVC sheets and are predator-proof, unlike the traditional wooden corrals which are vulnerable to predators (Loveridge and Hunt, 2016). Additionally, the mobile bomas benefit agricultural production, as the concentrated waste from the cattle held in the boma provides fertile ground for maize cultivation. Traditional wooden corrals are stationary and cannot be moved in order to plant crops (Loveridge and Hunt, 2016).

### 5.3.2. Survey design

The questionnaire was developed through literature review, conversations with staff at TKPP and in-depth qualitative interviews with individuals from the relevant communities using semi-structured interviews. For details on the selection of interviewers and participants, see section 2.2.1.It was

translated into the three main languages of the area: Ndebele, Nambya and Tonga, with convergence validity tests carried out for every question.

### 5.3.3. Piloting

This questionnaire went through three rounds of piloting, with each step accompanied by questions about the participant's view on the content of the question, the phrasing and the visual presentation. This was followed by open ended questions asking whether the participant could think of any additional points or issues that had not been addressed (in order to discover any omissions of issues that matter for the quality of life for people in the area) or ways to improve the phrasing or presentation of questions to make them easier to understand. The piloting was carried out in communities in the Mabale area, but not in the same villages where data collection was to take place. The pilots were carried out by the same team as carried out data collection (below).

### 5.3.4. Data collection

The data was collected as part of the same survey as used in Chapter 3 and 4. Survey responses (both the self-assessed life satisfaction and control variables) were recorded using the Qualtrics surveying platform (Qualtrics, 2017) by a team of 6 trained interviewers, employed solely for the purposes of this survey. 1 interviewer was female and 5 male. The interviewers were all from the region and spoke one or more of the local languages fluently. The villages visited were drawn randomly from the villages in the Mabale area within 30km of the border of the national park. 30km is the approximate distance that lions in the area move (except when dispersing) and conflict-intensity drops of sharply after this point (Kuiper et al., *unpublished*). We attempted to interview every person in every household in the target villages above the age of 18, with the exception of households that had been visited for the exploratory qualitative interviews or anyone who was visibly under the influence of alcohol. Individuals in 593 different households in 20 different villages were interviewed. For details on accounting for the non-dependence of individuals' data, see section 5.3.7. Everyone was interviewed individually, without other people present.

The question used to estimate subjective wellbeing was as follows:

"Overall, how satisfied are you with your life nowadays? (please consider of all aspects of your life: health, work, finance, family life and so on)"

| Not at all | | | | | | | | | | Completely |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

This question aims to estimate evaluative wellbeing and was based on MacKerron and Mourato (2013) who used the same scale from 0 ('Not at all') to 10 ('Extremely'). The participants were shown the scale on the tablets used to conduct the interviews, and this data was collected along with the other survey questions that form the basis of this thesis.

We included several control variables that have been empirically established to predict wellbeing: age, gender, ethnicity, education, health, religion, perceived comparative wealth status, marital status, fear of crime, and several metrics of social capital (frequency of socialisation with friends/family, perceived support within community and participation in organisations and clubs). For a comprehensive description and *a priori* hypotheses for each variable, please see Table 1 The variable type and structure of the variables used in the wellbeing regression are outlined in Table 2.

Table 1. Hypotheses supporting the selection of variables

| Variable | Hypothesised relationship to response variable | Supporting references |
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| | | |
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| "Overall, how satisfied are you with your life nowadays? (please consider of all aspects of your life: health, work, finance, family life and so on)" | Response variable | MacKerron and Mourato (2013); Dolan et al. (2011) |
| Name of village | This is used as a random variable to control for site-specific variation. | Ballas and Tranmer (2012) |
| Gender | Females expected to have lower happiness due to disempowerment. | Dolan and Metcalf (2008) |
| "What is your mother tongue?" (indicator of ethnicity) | Ethnicities expected to differ in their level of agreement with response variable | Agarwala et al. (2014) |
| "How old are you?" | Expect a U-shaped relationship with age, as this has been demonstrated in several wellbeing studies. | Dolan and Metcalf (2008), MacKerron (2012) |
| "To what degree do you feel that your household benefits from the presence of Hwange National Park?" | Positive relationship with response variable. Receiving benefits from wildlife-related activities are hypothesised to lead to higher levels of wellbeing due to tangible (e.g. employment) and intangible benefits (e.g. existence value, amenity value) | Coad et al. (2008) |
| "To what degree does fear of lions interfere with your daily activities? (such as going to school, fetching water, going to visit friends or relatives, or other activities)" | Negative relationship with response variable, due to psychological stress and opportunity costs. | Barua et al. (2013), Dolan et al. (2008) |
| "How many livestock have you lost to lions in the last 3 years?" | Negative relationship with response variable. Increased tangible losses to lions is hypothesised to reduce wellbeing, due to financial impact and psychological trauma. The 3 year period was established as the longest that participants could accurately remember in the piloting process. | Bhattarai and Fischer (2014), Holmern et al. (2007), Marchini and Macdonald (2018), Barua et al. (2013) |
| "Have you ever lost livestock to lions?" | Negative relationship with response variable. Increased tangible losses to lions is hypothesised to reduce wellbeing financial impact and psychological | Bhattarai and Fischer (2014), Holmern et al. (2007), Marchini and Macdonald (2018), Barua et al. (2013) |

| | | |
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| | trauma. It is not known what time scale is most influential on attitudes, so both this variable and the above livestock loss variable were recorded. | |
| "How often do you think lions come onto your village lands?" | Negative relationship with response variable. Increased perceived risk of encounters of lions for people and livestock was hypothesised to reduce wellbeing due to emotional reponses and increased perceived risk. | Inskip et al. (2014), Naughton-Treves and Treves (2005) |
| "Do you know personally anyone who has been attacked by a lion?" | Negative relationship with response variable. Personally knowing victims of lion attack is hypothesised to reduce wellbeing through emotional responses and increase perceived risk. | Naughton-Treves and Treves (2005), Sillero-Zubiri et al. (2007) |
| "What is your level of education?" | Positive relationship with response variable. Education level is hypothesised to be associated with higher wellbeing through personal satisfaction and increased employment opportunities. | Agarwala et al. (2014) |
| "How often do you attend church or other religious ceremonies?" | Positive relationship with response variable. Religious participation has been shown in numerous studies to be associated with increased wellbeing. | MacKerron (2012) |
| "How important do you think traditional ceremonies (such as rainmaking, ukuthethela and traditional memorial ceremonies) are for the wellbeing of your community?" | Positive relationship with response variable. Religious beliefs has been shown in numerous studies to be associated with increased wellbeing. | MacKerron (2012) |
| Total wealth (individual's wealth from all sources; value of livestock, crops, employment and informal work) | Positive relationship with response variable. Numerous studies have found a positive relationship between wealth and wellbeing in developing countries. | Conceição and Bandura (2008) |
| "Do you or anyone in your household own livestock (cattle, goats, poultry and so on)?" | Positive relationship with response variable. Livestock has monetary and cultural value, as well as | Scoones (1992) |

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| | serving as an insurance against crop failure. | |
| Proportion of wealth derived from non-animal sources | Positive relationship with response variable. Less dependence on livestock is hypothesised to be associated with higher wellbeing due to lower vulnerability of damage to the individual's livelihood. | Holmern et al. (2007), Suryawanshi et al. (2014), Romanach et al. (2007), Tessema et al. (2010) |
| "How satisfied are you with your current standard of living (material circumstances)?" | Positive relationship with response variable. Wealth has been shown to be related to attitude to carnivores. Work within the field of economics has shown that sometimes the level of satisfaction with own wealth is more influential on people's attitudes as absolute wealth is sensitive to shifting baselines. | Graham (2010) |
| No one else is responsible for lion depredation | Positive relationship with response variable. If the risk and losses associated with lions are perceived to be externally imposed, it may be resented to a greater extent. | Dickman (2010), Skogen et al. (2013) |
| Proportion of life spent in Hwange | Positive relationship with response variable. Being embedded within communities that have existed the area for a long time might to lead to higher wellbeing due to stable social structure, and knowledge of how to manage risks from wildife, so immigrants were hypothesised to have lower wellbeing. | Simich et al. (2009), Røskaft et al. (2003), Hariohay et al. (2018) |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | Negative relationship with response variable. This variable was included because wellbeing may be shaped by the conflict level experienced in the community, rather than losses incurred to the individual household. | Kideghesho et al. (2007), Sillero-Zubiri et al. (2007) |
| Experienced crop raiding (by elephants, baboons, quelea birds, bush pigs, cattle or similar) | Negative relationship with response variable due to financial impact and psychological trauma | Bhattarai and Fischer (2014), Holmern et al. (2007), Marchini and Macdonald (2018), Barua et al. (2013) |
| In your household, who makes most decisions on how money is spent? | Negative relationship with response variable. Increased financial emancipation is | Salignac et al. (2020) |

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| | hypothesised to be associated with higher levels of wellbeing. | |
| Considering the last 12 months, how are you feeling physically? | Positive relationship with response variable. Health has repeatedly been shown to be an important determinant of wellbeing. | Conceição and Bandura (2008) |
| How do you feel your wealth compares with the rest of your village? | Positive relationship with response variable. Comparative wealth may be more influential than absolute wealth, due to the importance of baselines for perception. | Conceição and Bandura (2008) |
| What is your marital status? | Being married is frequently found to increase wellbeing. | Dolan and Metcalf (2008), Conceição and Bandura (2008), Kohler et al. (2005), Ferrer-i-Carbonell (2013) |
| How often do you meet socially with friends, or relatives who live in other homesteads? | Positive relationship with response variable. Higher frequency of social interactions have been found to be positively associated with wellbeing in large numbers of studies. | Bruni (2010), Dolan and Metcalf (2008), Helliwell (2014) |
| Please tell us to what extent you feel that people in your local area help each other? | Positive relationship with response variable. This is a metric of social capital, which has been demonstrated to influence wellbeing in many contexts. | Halpern (2010), Bruni (2010), Dolan and Metcalf (2008), Helliwell (2014) |
| Please take a moment to think of any groups, clubs or organisations you take part in. These could be bible groups, choir, sport clubs, or any other groups, clubs or organisations. In the last month, how often did you take part in all these groups, clubs or organisations combined? (not including attending church services) | Positive relationship with response variable. This is a metric of social capital, which has been demonstrated to influence wellbeing in many contexts. | Bruni (2010), Dolan and Metcalf (2008), Helliwell (2014) |

Table 2. Variable types, question wording and answer scales. Summary statistics given in brackets.

| Variable | Answer scale |
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|---|---|
| Life satisfaction: “Overall, how satisfied are you with your life nowadays? (please consider of all aspects of your life: health, work, finance, family life and so on)” | Ordinal categorical: 0 (Extremely dissatisfied, 16%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Extremely satisfied, 16%) |
| Name of village | Nominal categorical |
| Gender | Nominal categorical: Male (44%), Female (56%) |
| Ethnicity: “What is your mother tongue?” | Nominal categorical: Ndbele (67%), Nambya (15%), Tonga (13%), Other (5%) |
| Age: “How old are you?” | Continuous numeric (range = 18-94) |
| Perceived degree of benefits accruing from the protected area: “To what degree do you feel that your household benefits from the presence of Hwange National Park?” | Ordinal categorical: Don't benefit at all (69%), Benefit a little (11%), Moderately benefits (12%), Benefit strongly (6%), Very strongly benefits (2%) |
| Level of fear of lions: “To what degree does fear of lions interfere with your daily activities? (such as going to school, fetching water, going to visit friends or relatives, or other activities)” | Ordinal categorical: Doesn’t interfere at all (12%), Barely interferes (9%), Moderately interferes (20%), Severely interferes (21%), Very severely interferes (38%) |
| Number of livestock lost to lions: “How many livestock have you lost to lions in the last 3 years?” | Continuous numeric (range = 0-58) |
| Whether respondent has ever lost livestock to lions: “Have you ever lost livestock to lions?” | Nominal categorical: Yes (39%), No (60%), Not sure (1%) |
| Perceived frequency of lion incursion onto village land: “How often do you think lions come onto your village lands?” | Ordinal categorical: Never (7%), A few times per year (10%), Every month (19%), Every week (61%), Every day (3%) |
| Personally know someone attacked by lion: “Do you know personally anyone who has been attacked by a lion?” | Nominal categorical: Yes (43%), No (57%) |
| Education: “What is your level of education?” | Ordinal categorical: None (5%), Primary (33%), Secondary (57%), Tertiary (5%) |
| Degree of religious observance: “How often do you attend church or other religious ceremonies?” | Ordinal categorical: Never (9%), Rarely (9%), Once a month (2%), Several times a month (5%), Once a week (53%), Several times per week (22%) |
| Importance attached to traditional religion: “How important do you think traditional ceremonies (such as rainmaking, ukuthethela and traditional memorial ceremonies) are for the wellbeing of your community?” | Ordinal categorical: Not important at all (41%), Somewhat important (8%), Moderately important (8%), Very important (24%), Extremely important (19%) |

| | |
|---|---|
| Total wealth in US$ (individual's wealth from all sources; value of livestock, crops, employment and informal work) | Continuous numeric: Sum of individual's wealth from all sources; livestock, crops, employment and informal work (range = 10 - 15316) |
| Whether own livestock: “Do you or anyone in your household own livestock (cattle, goats, poultry and so on)?” | Nominal categorical: Yes (90%), No (10%) |
| Proportion of wealth derived from non-animal sources | Continuous numeric: total value of non-animal wealth divided by total wealth (range = 0.02-1) |
| Satisfaction with material circumstances: “How satisfied are you with your current standard of living (material circumstances)?” | Ordinal categorical: 0 (Extremely dissatisfied, 12%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Extremely satisfied, 12%) |
| External responsibility for risk: “Who do you think is responsible for your losses to predation?” | Open question categorised into a binary nominal categorical variable: Somebody else is responsible (69%), Nobody else is responsible (31%) |
| Proportion of life spent in Hwange | Continuous numeric: Years lived in Hwange divided by age (range = 0.01-1) |
| Conflict level: The number of livestock lost and injured per village (statistics collected by Trans-Kalahari Predator Programme) | Continuous numeric (range = 0-137) |
| Experience of other wildlife damage: “Have you suffered any of the following to yourself or in the close family last 12 months? Crop raiding (by elephants, baboons, quelea birds, bush pigs, cattle or similar)” | Nominal categorical: Yes (66%), No (34%) |
| Ownership of wealth: “In your household, who makes most decisions on how money is spent?” | Nominal categorical: Me (28%), Someone else (32%), Equally shared with someone else (40%) |
| Physical health: “Considering the last 12 months, how are you feeling physically?” | Ordinal categorical: 0 (Very unwell, 6%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Very well, 37%) |
| Perceived relative wealth: “How do you feel your wealth compares with the rest of your village?” | Ordinal categorical: A lot worse (5%), A bit worse (22%), About the same (22%), A bit better (49%), A lot better (2%) |
| Marital status: “What is your marital status?” | Nominal categorical: Single (26%), Married (61%), Widow/widower (9%), Divorced (4%) |
| Frequency of socialisation with friends/family: “How often do you meet socially with friends, or relatives who live in other homesteads?” | Ordinal categorical: Every day (12%), Several times per week (9%), Once a week (7%), Several times per month (10%), Once per month (12%), rarely (49%), never (1%) |

| | |
|---|---|
| Helpfulness and support within community: “Please tell us to what extent you feel that people in your local area help each other?” | Not at all (17%), A little bit (24%), Moderately (19%), To a great extent (31%), To a very great extent (9%) |
| Participation in organisations and clubs: “Please take a moment to think of any groups, clubs or organisations you take part in. These could be bible groups, choir, sport clubs, or any other groups, clubs or organisations. In the last month, how often did you take part in all these groups, clubs or organisations combined? (not including attending church services)” | Continuous numeric (range = 0-23) |

### 5.3.5. Data exploration

Using the FactoMineR package in R, we carried out factor analysis for mixed data (FAMD) to explore the potential for reducing the number of covariates by generating summary factors, but the axes generated did not summarise a substantial part of the total variability.

We checked the specification of the mean structure and heteroscedasticity using covariate plots. We also tested for the appropriateness of the logit link function by comparing QQ plots for models with different link functions and by carrying out an ANOVA test. We found no evidence that a logit link was not adequate.

We ran Spearman’s rank correlation test on all combinations of numeric and ordinal variables, with a correlation coefficient cut-off threshold of 0.70 identifying problematic collinearity (Dormann et al., 2013). We ran Kruskal-Wallis tests on combinations of numeric to nominal and ordinal to nominal variables. Combinations of nominal variables were examined using Cramer’s V, with a cut-off criterion of 0.5. Values of Cramer’s V above 0.4 and 0.6 indicates “relatively strong” and “very strong” similarities among variables, respectively (Ellis et al., 2010, Rea and Parker, 2014). These three statistics are not comparable, as Spearman’s and Cramer’s V yield measures of degrees of association (Friendly and Meyer, 2015). These tests were used in combination with variance inflation factors (VIFs). VIFs above the value 10 indicate a serious collinearity problem (Lin, 2008). All VIFs for

models presented here had VIFs below 2, showing that there are not problematic levels of collinearity between any variables included in the same model.

### 5.3.6. Exploration of wealth metrics

Economic valuation estimates using the life satisfaction method are sensitive to the size of the coefficient of the wealth variable. As wealth can be measured and delineated in several ways, it was important to carry out sensitivity tests using different wealth metrics and model specifications. We ran the regression model using only cash income (in case access to cash was more influential on wellbeing than total wealth), income from cash and crops only (in case the inclusion of livestock in our wealth metric was confounding our results) and cash income when controlling for the average wealth of the village (to control for peer effects). All wealth metrics yielded extremely similar value estimates: every likelihood ratio test p-values was lower than 0.5 when comparing the models with the different wealth specifications.

### 5.3.7. Analysis

We used ordinal logistic regression mixed models, treating "village" as a random variable to account for the spatial clustering of respondents in each village. The clmm function in the package "ordinal" was used in R version R-3.5.3 (Christensen, 2018). Individuals that share the same homestead are not independent samples, so to check for any effect caused by clustering within households I created a nested version of the wellbeing regression, where individuals are nested within homesteads which are nested within villages, and used a likelihood ratio test to see if the nested models differed significantly from the non-nested models. They did not differ ($p>0.1$) which means that there was no statistically detectable confounding effect of increased level of similarity in the answers of participants in the same household.

5.3.8. Assumption testing:

Ordinal response models improve on the previous treatment of ordinally scaled responses as continuous. Testing the fit of ordinal models has until recently been problematic but recent work has shown that 'surrogate' residuals can be used (Liu and Zhang, 2018, Greenwell et al., 2018). We used the R "sure" package (Greenwell et al., 2018), to extract residuals and tested the proportional odds assumption of ordinal models both graphically and statistically. The graphical method was carried out as outlined by Liu & Zhang 2018 (Liu and Zhang, 2018). Neither the graphical methods nor the statistical test revealed any problematic breaches of the proportional odds assumption. The level of collinearity is quantified in the VIF tables in Supplementary materials (table S1).

5.3.9. Estimating economic value

We used the coefficients for wealth (the exponent of the log income) and the variable pertaining to ever having experienced livestock loss, to estimate the increase in annual wealth that would be necessary to give an equivalent wellbeing score as if not having experienced livestock loss. We used the log of income to account for the diminishing marginal utility of money (one dollar means more to a poor person than to a rich person). The economic value is estimated by dividing the coefficient of the variable we want to value by the coefficient of the income variable (adjusting for the logistic scale since it is an ordinal logistic regression).

5.3.10. Approach to statistical significance and strength of evidence

Through this thesis I have followed the approach towards statistical significance outlined by Amrhein et al. (2019). It is a statement with more than 800 signatories, which calls for a move away from significance thresholds and towards reporting degrees of strength of evidence. Throughout this thesis I report results according to degree of evidence for an association with the response variable. In the results tables this is indicated with the symbols "." (indicates very low significance level), "*" indicates low level, "**" indicates intermediate level, and "***" indicates high significance level.

There is no cut-off level, only degrees of strength of evidence. P-values < 0.1 will be considered evidence that is adequately strong to be worth discussing, as is common in the field of economics (e.g. Goerke and Pannenberg (2015), Schläpfer (2006), Mourato and MacKerron (2010), Bakhshi et al. (2015), Perez Loyola et al. (2021), Armstrong et al. (2019), Fang et al. (2021), Milovanska-Farrington and Farrington (2021), Kumagai (2021), Baldursdottir et al. (2021), Krys et al. (2021), Faccioli et al. (2020), Dardanoni and Guerriero (2021)). To make the strength of evidence clear, the p-value is given not only in the results tables but also as part of the text in the results section. Furthermore, when discussing the variables in the discussion section, the strength of the evidence is mentioned when relevant. Note that the strength of influence of a variable on a model does not relate to p-values but to effect sizes.

## 5.4. RESULTS

1482 people participated in the survey. 97% of people asked to participate complied. The mean age of participants was 38 years, 43.9% of the participants were males and 56.1% were female. 66% of participants were Ndebele, 15% Nambya, 13% Tonga and 6% belonged to other ethnicities. The median life satisfaction was 6, on a scale from 0 (not at all satisfied) to 10 (completely satisfied). While 62% had attended secondary education or higher, 5% had received no education. 39% of participants stated they had experienced livestock loss to lions, 60% had never lost livestock to lions, and 1% of people were unsure (the unsure individuals were excluded from the analysis). 90% of people owned livestock, the mean number of livestock lost to lions in the last 3 years among all participants was 2 (standard deviation = 5.27), and 69% of participants assigned responsibility for the loss to another person or organisation. 66% of participants had experienced other types of costs inflicted by wildlife such as damage to seed crops quelea birds (*Quelea spp.*). The median number livestock owned was 2 among the whole population. The median wealth was US$1059, while the

proportion of wealth from sources unrelated to livestock, such as employment or sale of wild fruits, had a median value of 70%. The majority of participants considered their wealth level to be slightly higher than that of the rest of their community. The median rating of satisfaction with material circumstances was 5 on a scale ranging from “Extremely dissatisfied” (0) to “Extremely satisfied” (10). 40% of participants said that the decisions of how money is spent was equally shared with someone else in the household. The median proportion of a person’s life spent in the Hwange area was 85%. 64% of people thought lions come into village lands every week or more often but 52% of participants had never seen a lion. 43% of people said they personally knew someone who had been attacked by a lion. The median response to the question of to what degree fear of lions interferes with their daily activities was “Severely interferes”. Only 31% of participants perceived there to be any benefits to their household from the presence of the national park and 78% of people stated that there were no positive aspects of having lions in their area.

We found that several variables relating to lions and conservation had a relationship with people’s wellbeing that was strong enough to be detectable in their life satisfaction, with serious implications for lion conservation (Table 3). Fear of lions ($p=0.10$) and having experienced livestock loss to lions ($p=0.10$) was slightly associated with lower subjective wellbeing. Owning livestock ($p<0.001$) was also associated with higher subjective wellbeing, while higher levels of perceived benefits ($p<0.01$) accruing from the national park was associated with greater wellbeing. Several factors that are known to influence wellbeing were included to control for variation (Table 3). As expected, we found evidence that wellbeing is positively impacted by wealth (in logarithmic form) ($p<0.01$), perceived comparative wealth (how wealthy you perceive yourself to be compared to your peers)( $p<0.001$), health ( $p<0.001$), and frequency of social interactions ( $p<0.001$), and that certain ethnicities report higher wellbeing (the p-value of the ethnicity Nambya relative to Ndebele as the reference level was $p<0.04$, and the p-value for Tonga was $p<0.01$) . Wellbeing was negatively associated with age ($p=<0.001$) and education level ($p=0.01$). We also investigated a novel hypothesis about household

power dynamics: equally shared ownership of wealth within the household was associated with higher wellbeing (p=0.06).

Table 3. Estimates, standard error (SE), p-values and significance level for the ordinal logistic life satisfaction regression (subjective wellbeing). "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| Variable | Estimate | SE | P-value | * |
|---|---|---|---|---|
| Age | -0.03 | <0.01 | <0.001 | *** |
| Gender Female (reference level: "male") | 0.12 | 0.11 | 0.30 | |
| Ethnicity Nambya (reference level: "Ndebele") | -0.32 | 0.16 | 0.04 | * |
| Ethnicity Tonga | 0.48 | 0.15 | <0.01 | ** |
| Ethnicity other | 0.09 | 0.21 | 0.68 | |
| Perceived household benefits from national park | 0.51 | 0.16 | <0.01 | ** |
| Fear | -0.21 | 0.12 | 0.10 | . |
| Owns livestock (reference level: "does not own livestock") | 0.89 | 0.19 | <0.001 | *** |
| Has ever lost livestock to lions (reference level: Yes) | 0.26 | 0.12 | 0.03 | * |
| Do not personally know someone who has been attacked by lion (reference level: "personally know someone") | -0.04 | 0.11 | 0.67 | |
| Education | -0.48 | 0.20 | 0.01 | * |
| Physical condition | 0.63 | 0.19 | <0.001 | *** |
| Religiousness | 0.10 | 0.14 | 0.46 | |
| Proportion of non-animal wealth | -0.21 | 0.19 | 0.28 | |

| | | | | |
|---|---|---|---|---|
| Perceived comparative wealth | 0.90 | 0.17 | <0.001 | *** |
| Nobody is responsible for losses to lions (reference level: "someone else is responsible for losses to lions") | 0.14 | 0.11 | 0.20 | |
| Proportion of life spent in Hwange | -0.02 | 0.15 | 0.92 | |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | <0.01 | <0.01 | 0.99 | |
| No ownership of wealth (reference level: "full ownership of wealth) | -0.06 | 0.14 | 0.68 | |
| Partial ownership of wealth | 0.24 | 0.13 | 0.06 | * |
| Experienced other wildlife-related harm (reference level: "not experienced other wildlife-related harm) | -0.11 | 0.11 | 0.29 | |
| Marital status: Married (reference level: single) | -0.08 | 0.14 | 0.53 | |
| Marital status: Widow/widower (reference level: single) | 0.19 | 0.23 | 0.40 | |
| Marital status: Divorced (reference level: single) | -0.22 | 0.27 | 0.42 | |
| Frequency of socialisation with friends/family | 0.90 | 0.14 | <0.001 | *** |
| Helpfulness and support within community | 0.09 | 0.13 | 0.47 | |
| Worry about crime | 0.12 | 0.10 | 0.22 | |
| Participation in organisations and clubs | <0.01 | 0.01 | 0.69 | |
| Wealth (log transformed) | 0.15 | 0.05 | <0.01 | ** |
| Number of livestock lost personally last 3 years | 0.02 | 0.01 | 0.12 | |
| Perceived frequency of lions entering village lands | 0.02 | 0.19 | 0.92 | |

The effects of the explanatory variables on life satisfaction scores were greatest at the extremes, with less pronounced association between the explanatory variables and wellbeing at intermediate levels of wellbeing (Figure S1 – S12, Supplementary materials).

Table 4. Effect sizes of variables with p-value under 0.1. These are the effects of moving from the lowest to the highest end of the X-axis on the probability of achieving the highest life satisfaction rating.

| Variable | Effect size |
|---|---|
| Age | 0.20 |
| Wealth | 0.13 |
| Owns livestock (reference level: "does not own livestock") | 0.13 |
| Frequency of socialisation with friends/family | 0.13 |
| Perceived comparative wealth | 0.13 |
| Ethnicity | 0.10 |
| Perceived household benefits from national park | 0.09 |

| | |
|---|---|
| Education | 0.08 |
| Physical health | 0.07 |
| Shared ownership of wealth | 0.04 |
| Has lost livestock to lions | 0.03 |
| Fear | 0.03 |

### 5.4.1. Economic valuation estimate for experiencing livestock loss

For a person with income at the 25$^{th}$ percentile (US$500), the impact on wellbeing associated with having experienced livestock loss to lions was equivalent to a change in income of US$2900, for a person with the median income (US$1058) it was equivalent to US$5800, and for a person at the 75$^{th}$ percentile (US$2243) the value was equivalent to US$13000 annually. This provides a metric for quantifying wellbeing impacts, and also provides an economic equivalent of such impacts for the purposes of compensation policies.

## 5.5. DISCUSSION

### 5.5.1. Wellbeing and lion presence

Several aspects of lion presence leave lasting impacts on the wellbeing of the people who live alongside them. This has serious implications for conservation practice in areas with lions, and for similar situations where people live with large predators or other potentially dangerous wildlife in close proximity. The experience of losing livestock to lions had a detectable association with subjective wellbeing (measured in terms of life satisfaction), though the evidence was weak (p=0.3). Economic valuation placed this harm to the value of US$5800 per year (for a person of median income). This impact is seemingly dramatic, but needs to be interpreted in context: when using the life satisfaction method, economic value is estimated in terms of the equivalent effect of wealth on wellbeing. As is often the case, our analysis showed that the impact of wealth on wellbeing is slight, so the amount that a person's wealth would have to increase for that person to be as happy as if

he/she had never suffered livestock loss to lions is therefore large. Moving from the lowest to the highest end of the wealth distribution increases the probability of having the highest life satisfaction score by only 13% (Table 4). The economic value derived using this method are not directly comparable to those derived in chapter 4. Compared to the other statistically significant variables, the effect of having experienced livestock loss is among the smallest. Only the effects of fear and ownership of wealth are comparably low. Having experienced livestock losses reduces a person's probability of having the highest life satisfactions score by 3% (Table 4). However, this does not trivialise the impact of livestock predation on people's wellbeing – just the fact that experiencing livestock loss at some point in the past leaves a statistically detectable mark on someone's long-term wellbeing indicates the severity of such experiences.

The estimated economic value of the harm caused by experiencing livestock predation by lions (US$5800 per year) has implications for conservation initiatives that aim to offset the costs of coexisting with wildlife in terms of improved finances (such as compensation or economic development projects). Because the effect of wealth on wellbeing is so low, the amount of increase in wealth required to equal the impact on wellbeing of living with wildlife in financial terms is very large. Offsetting an impact of US$5800 per person per year is unrealistic in the vast majority of contexts. It might be possible to achieve more cost effective increases in wellbeing by working towards improving other factors that influence wellbeing. The effect size of moving from the lowest to the highest level of education and health was 0.08 and 0.07 respectively. These are lower than the effect size of wealth (the effect of moving from the lowest wealth level to the highest was 0.13) but, depending on the cost of healthcare and education, it may be possible to provide greater increases in wellbeing with finite project funds through healthcare and education. This is because though the effect size of wealth is higher, it covers a large span in wealth levels (the highest wealth in the sample was US$15 000). So it might be possible to move to higher levels of health and education at lower cost than the increases in wealth required to yield equivalent improvements in wellbeing (in

this particular context the effect of education on wellbeing was negative, but in many contexts it is positive depending on the opportunities education offers in the area (MacKerron, 2012). It is also worth keeping in mind that the strength of evidence for an association between wellbeing and education was very low (p=0.01), so the chance of a type I error is higher than for the variables with lower p-values (Agresti and Finlay, 2009). The evidence for the association of wealth on wellbeing was low (p<0.01) and the evidence for an association with health was strong (<0.001). Of course, higher wealth increases access to health services and education, but direct investment may leverage improvements more effectively. This approach is appropriate if the motivation is normative, i.e. the goal is to offset the negative effects of wildlife populations for ethical reasons. However, if the aim is to achieve conservation goals, then offsetting impacts on wellbeing suffer from several problems. Firstly, the link between the benefits and wildlife may not be clear to people, so the improvements in wellbeing may not induce any changes in attitudes. Secondly, attitudes may not translate to behaviour. Factors extrinsic to the individual also influence behaviour (Heberlein, 2012). Third, even if the connection is made clear through communication or information campaigns, there may be no incentive to change behaviours as the benefits are not tied to conservation outcomes. Whether education or the provisioning of services such as healthcare is an effective conservation strategy is debatable with mixed evidence for both conservation interventions (Schultz, 2011, Waylen et al., 2010). Such services are usually provided as part of Integrated Conservation and Development Programs (ICDPs) or Payment for Ecosystem Services (PES), where communities are consciously aware of an explicit link between the services provided and the provisioning of conservation outcomes (Coad et al., 2008). However, this study does not make the suggestion to provide education and healthcare on the basis of achieving conservation outcomes, but purely for the purposes of off-setting the negative effects on wellbeing from the presence of lions, should any actor be interested in doing that from a normative and ethical perspective. The link between lion presence and wellbeing that is established through the wellbeing regression refers to a statistical relationship and does not claim to show any conscious link between lions and wellbeing in the minds

of the participants. Therefore there are no grounds to recommend PES or ICDPs based on the results of this study.

The actors that might wish to offset the impact on local people's wellbeing associated with the presence of lions could be para-statal actors such as the Zimbabwe Parks and Wildlife Management Authority, or non-state actors such as non-governmental conservation organisations (NGOs). If conservation NGOs decide to provide services such as education or healthcare, that raises questions about the legitimacy of NGOs to provide services that are usually within the remit of the state (Jepson and Canney, 2003). If civil society organisations articulate their goals in terms consistent with development policy, there is a risk that they become instrumentalities of the state (Jepson and Canney, 2003) which can undermine both conservation outcomes and the rights of local communities (Kashwan, 2013).We included metrics of both objective risks (total number of livestock killed or injured in the village area between 2008 and 2019 and having experienced livestock loss) and perceived risk (perceived frequency of lion presence on village land) of harm from lions to investigate whether both objective and perceived risks lead to detectable impacts on wellbeing. Only the objective risk at the personal level (personally having lost livestock), as opposed to community level risk (as indicated by the number of livestock killed or injured by lions in the village area), was associated with wellbeing at low level of strength of evidence ($p=0.03$). This indicates that personal losses are more influential than general conflict levels, and that conflict mitigation strategies are the more efficiently applied to the individual level rather than at the community level.

Having experienced livestock loss to lions is not the only aspect of lion presence that was linked to people's wellbeing. Fear also appears to have a significant effect on subjective wellbeing, but the evidence is weak ($p=0.10$) and the effect size is small. Moving from the lowest to the highest fear level had an effect of similar magnitude to ever having lost livestock. Not all effects of living close to the protected area are negative. Increased levels of perceived benefits accruing to the household from Hwange National Park was associated with higher wellbeing at a similar magnitude to the

effect of health and education and with robust evidence ($p<0.01$). However, only a small portion of the population perceive such benefits: 69% of people perceived no benefit at all from the national park. Improving the transfer of benefits from the national park to the surrounding communities provides a promising (though challenging) avenue for balancing the negative effects of the presence of the national park. Lions are only one of several species of wildlife that causes harm to the livelihoods of the people living alongside the park: hyaenas and leopards also predate livestock, and elephants damage crops (Dube, 2019). The total impact of wildlife harm on people's wellbeing is therefore likely to be greater than the harm revealed by this study. Even though there was evidence for the impact of having lost livestock being associated with wellbeing, there was no evidence that the number of livestock lost in the last 3 years was associated with wellbeing. This effect may not be detectable due to the limited time-frame of 3 years, and because losing livestock may be experienced as a traumatic event which qualitatively changes your wellbeing state, rather than a source of harm that scales with the magnitude of livestock losses. Owning livestock is associated with higher wellbeing.

There was no evidence that personally knowing someone who had been attacked by a lion influences wellbeing. This was unexpected as fear did have an association with wellbeing. However, almost all participants had heard of someone who had been attacked, so the lack of effect of personally knowing someone who had been attacked may be because personally knowing someone does not increase your concern beyond what is caused by hearing about attacks on people. If so, the formative importance of second-hand stories of lion attacks on humans should be recognised in conflict mitigation efforts.

#### 5.1.2. Wellbeing in Mabale in the context of the life satisfaction literature

The wellbeing regression model also casts light on variables that do not relate to lion presence. The effect sizes were stronger than those relating to lion presence. There was strong evidence that the

frequency of socialisation with friends and relatives was positively associated with wellbeing ($p<0.001$), as expected. Social relationships are consistently found to be important for human wellbeing across cultural contexts Bruni (2010), Dolan and Metcalf (2008), Helliwell (2014). There was also strong evidence that higher comparative wealth, which refers to how wealthy people perceive themselves to be relative to their peer-group, was associated with higher wellbeing ($p<0.001$). The life satisfaction literature shows that in some communities, relative wealth is a better predictors of wellbeing than absolute wealth (Conceição and Bandura, 2008). In the case of the communities participating in this study, both comparative and absolute wealth contributed to explaining variation in wellbeing. The strength of evidence for comparative wealth was stronger (as the p-value was smaller) but the effect sizes were the same for comparative and absolute wealth. There was also strong evidence that physical condition was also associated with higher wellbeing ($p<0.001$) as healthier people who are in better condition tend to be happier, which is an almost universal finding in wellbeing studies (Conceição and Bandura, 2008).

The association between education and wellbeing was negative. The life satisfaction literature finds mixed results with regards to the effect of education on wellbeing. In some instances, education increases wellbeing, likely due to societal benefits that accompany education. In other cases, education is associated with lower levels of wellbeing (Michalos, 2008), as these results show to be the case in the communities in Mabale. The most consistently supported explanation for this negative relationship is that more educated people require better circumstances to feel satisfied (Kristoffersen, 2018).

There were differences in self-reported life satisfaction between ethnicities in the study area. This conforms to expectation, as the literature on life satisfaction frequently finds statistical differences in the self-assessed wellbeing of different ethnicities when controlling for confounding variables (Agarwala et al., 2014). However, the causes for such differences are debated. When comparing self-reported life satisfaction scores between respondents in surveys that have been administered in

different languages, the differences observed may be an artefact of linguistic differences in how the question is interpreted rather than correspond to a real difference in wellbeing between different groups. This possibility cannot be eliminated entirely, but can be minimised through careful piloting and validity tests of the translation, and there are many sources of evidence that indicate that this source of bias is often small or non-existent (Kacapyr, 2008). Also, surveys where all respondents are surveyed in the same language frequently find statistically significant differences in wellbeing between ethnicities (Emerson et al., 2020). Another potential source of bias beyond the linguistic differences can be different cultural interpretations of what the same set of words mean, or different perceived baselines for comparison (Baujard, 2013). Therefore, is it not possible to make robust conclusions based on statistical differences in wellbeing between ethnicities.

Several variables that are often found to be associated with self-reported life satisfaction in the literature appear not to be associated with wellbeing in the Mabale area. Marital status, degree of religiousness, perceived helpfulness within the community (which is an indicator of social capital) and worry about crime were not associated with wellbeing. However, it is impossible to conclusively prove the absence of a relationship with a regression analysis. It is only possible to say that there is not a sufficiently strong association to be detectable with the sample size used in the regression.

## 5.6. CONCLUSION

The presence of lions demonstrably influences the wellbeing of the people who live alongside them. Both fear of lions and having experienced livestock loss to lions was associated with lower subjective wellbeing scores. For the communities along the border of Hwange National Park this impact is sufficiently great relative to the effect of wealth on wellbeing that offsetting harms experienced from the maintenance of lion populations is infeasible. For a person of median wealth, the impact of experiencing livestock predation by lions has an equivalent effect on wellbeing as a change in wealth

of US$5800. This may contribute to explaining the limited success of compensation schemes and other financial mechanisms as solutions to human-wildlife conflict.

## Statement of Authorship for joint/multi-authored papers for PGR thesis

To appear at the end of each thesis chapter submitted as an article/paper

| | |
|---|---|
| Title of Paper | Happiness and lions – the impact of living alongside lions on wellbeing |
| Publication Status | □Published □ Accepted for Publication<br>□Submitted for Publication □**X**Unpublished and unsubmitted work written in a manuscript style |
| Publication Details | |

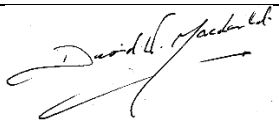
### Student Confirmation

| | | | |
|---|---|---|---|
| Student Name: | | | |
| Contribution to the Paper | I lead a team of research assistants to carry out data collection. Performed the analysis and wrote the manuscript.<br>Received help from Paul Johnson in figuring out the coding in R and the statistical tests.<br>The remaining co-authors contributed with advice on methodology and strategy, facilitated fieldwork, and commented on the paper through its development. | | |
| Kim C. Jacobsen | | Date | 6th September 2020 |

### Supervisor Confirmation

By signing the Statement of Authorship, you are certifying that the candidate made a substantial contribution to the publication, and that the description described above is accurate.

| |
|---|
| Supervisor name and title: |

| | | |
|---|---|---|
| Supervisor comments<br>Mr Jacobsen brought great originality and an enormous effort to this work, and led an expert team. His contribution was predominant and overwhelming. | | |
| Signature  | Date | 29.09.2020 |

# CHAPTER 6. CONCLUSION

## 6.1. Summary of main findings

### 6.1.1. Attitudes towards coexistence with lions

In my analysis of attitudes to coexistence with lions (Chapter 3) I found that intangible variables were as influential as tangible variables. Among the 15 variables with evidence for an association with attitudes to coexistence with lions, five pertained to tangible factors (number of livestock lost, whether someone they personally knew had been attacked by lions, perceived frequency of lions entering the village, how often they have seen lions, and whether they participated in the community guardian or mobile boma programmes) and four to intangible factors (fear, ecocentric values, traditional religion and how rooted the individual was in the Hwange area (indicated by the proportion of life spent in Hwange). One additional variable plausibly contained a mix of tangible and intangible aspects (the degree to which the household benefits from the national park), and five variables relating to demographics (age, gender, education, ethnicity and number of dependants. However, the strength of evidence (judged through p-values) and the number of variables with strong evidence for an association with the response variable are not the most informative ways to judge the relative importance of different variables because a variable with a slight but consistent association with the response variable can have a high p-value (Cumming, 2013). Effect size is

arguably a more informative metric when determining conservation policy priorities as this indicates how influential a variable is relative to the other variables in the model in terms of magnitude (Hanel and Mehler, 2019).

Equally many intangible as tangible variables were found to be in the highest tier of effect sizes, with fear being the variable with the largest effect size of all variables in the comprehensive model, which, based on AIC values, was the strongest candidate model. However, one of the variables with high effect size did not exclusively fit into either the tangible or intangible category: the perceived level of benefits arising from Hwange National Park was very influential, but this variable may contain a mixture of tangible and intangible factors. Indication of what benefits this variable entails comes from the qualitative interviews carried out prior to the design of the quantitative questionnaire. Respondents cited both tourism (yielding tangible financial benefits) and a desire for lions to be protected for the children to experience in the future (intangible existence value). It is not possible to provide percentages as this is qualitative data, where percentages would be a misleading statistic since the respondents are non-randomly sampled. It is, however, important to distinguish between effect size and prevalence in a population. Though the effect of perceiving substantial benefits accruing from the national park was very high, the absolute number of participants that stated any such benefits in the quantitative questionnaire was low (31% of respondents perceived there to be some benefits).

Socio-economic variables and quantitative metrics of material losses have been predominant in the HWC field for much of its history, and despite strong voices emerging for the importance of cultural, emotional and psychological factors to understand HWC (Browne-Nuñez and Jonker, 2008, Dickman, 2010, Dickman et al., 2013, Inskip et al., 2014) there is still a widespread reliance on such variables one group of participants did not have a negative preference towards increases i as predictors of human-wildlife conflict (Kansky and Knight, 2014). Several strands of evidence in Chapter 3 indicates that such an approach may yield misleading results. Firstly, in the comprehensive model, which

controls for a wide range of variables, only one socio-economic variable displayed an above average effect size: number of dependants. This indicates that socio-demographic variables may not be among the most influential in determining willingness to co-exist with large carnivores, at least in the location of this study (though of course causality cannot be determined with certainty in observational studies, and there is always the risk of an undetected underlying causal latent variable). Secondly, most socio-economic variables showed higher effect sizes when included in a thematic model containing only socio-economic variables. This shows the potential perils of mistakenly assigning inflated importance to socio-economic variables when insufficiently controlling for other types of variables, such as those related to perceptions or past experiences. Third, among the three thematic models, the model utilising only variables related to beliefs and perceptions performed better than the model containing only socio-economic variables. This shows that even if only focusing on one type of variable to make predictive models for pragmatic purposes, socio-economic variables are not necessarily the type of variable that performs the best. However, this will depend on the particular study system, and on what specific variables the researcher chooses for the thematic model (it is conceivable that if I had chosen a different set of variables within each theme, the relative predictive power of each model would have been altered). Nonetheless, this does illustrate the point that socio-economic variables should not unquestioningly be considered the best choice for predicting attitudes to wildlife. The variables that emerged as influential in Chapter 3 provide an advantageous starting point for researchers carrying out attitude analyses in other systems.

### 6.1.2. Quantifying preferences towards changes in lion populations, mobile bomas and community guardians

The choice experiments revealed that the overall preferences within my sample of participants from the Mabale area were, as expected: a negative preference towards increases in the local lion population and positive preferences towards mobile bomas and community guardians . Using a

latent class model showed that preference groupings exist within the population: one group of participants did not have a negative preference towards increases in the lion population (they were indifferent to both increases and decreases in the lion population), and one group of participants showed a negative preference towards monetary compensation payments. These preferences differed from my *a priori* expectations but were consistent with views expressed by a minority of participants in my initial qualitative interviews.

These preferences were linked to ecocentric values, fear of lions and trust in compensation initiatives. As expected, people with ecocentric values were less likely to have negative preferences towards lions, and people with higher levels of trust in compensations schemes expressed stronger preferences for compensation payments and less negative preferences for increases in the lion population. Higher levels of fear were associated with stronger negative preferences towards increases in the lion population. The effect of fear carries implications for how conflict mitigation initiatives are designed (e.g. greater investment in initiatives that reduce fear for personal safety and for the safety of livestock, such as the community guardians), but ecocentric values are unobservable and poorly understood so it is therefore difficult to use ecocentric values to direct conflict mitigation efforts.

The economic value estimate for the marginal lion was WTP of -US$180 annually based on the latent class model on high trust data. This means that when choosing between monetary payments and increased lion numbers, people were willing to give up any amount of money up to US$180 rather than having an additional lion in their local area. This value is substantially higher than the projected average additional livestock loss from an additional lion, though the expected increase in livestock loss is highly simplified and does not take into account pride dynamics, population trends in wild prey species or individual differences between lions in their livestock predation behaviour This discrepancy reveals, as would be expected from the results of the attitude analysis in Chapter 3, that the value of livestock losses only constitute a small portion of the total harm that people in the

Mabale area perceive from the presence of lions. As fear of lions is associated with stronger negative preferences, this provides an indication that the harm caused by fear, both in terms of the experience of the emotion and in its limiting effect on activities that the person would otherwise wish to carry out, constitutes part of these unobserved costs. The standard economic approach to assessing risk and costs is to do so in terms of averages (as that weights the magnitude of the negative outcome in proportion to the probability), however, as discussed in section 4.5.1., livestock losses are heterogeneously distributed, and the people in the area might be thinking about loss scenarios rather than loss weighted by probability. The maximum loss recorded by the TKPP in a single incident through in the time covered in their records (2008 – 2020) was US$1484 in terms of market value of the livestock lost. So all the estimates fall within the range of possible losses.

Preferences towards mobile bomas and community guardians are positive in all groups within the population, but there is some heterogeneity in relative preferences. 41% of the population (the largest class) is estimated to prefer mobile bomas over community guardians, while the remainder prefers community guardians. This shows that both conflict mitigation initiatives receive fairly even support in the area, but there is an overall preference for community guardians. However, if considering only the two classes with negative preferences to increases in lion numbers (the most relevant groups for conflict mitigation efforts), then preferences are nearly equal for each of the two initiatives (41% preferring mobile bomas versus 37% preferring community guardians).

The WTP estimates for community guardians and mobile bomas appear implausibly high. This may partially be due to these programs really having high value to participants: bomas are very effective at reducing livestock loss for several species of predator, gives dramatic increases in maize harvests by fertilising the ground below the bomas which can consequently be converted to a field, and reduces the risk of potentially lethal night-time encounters between predators and livestock owners protecting their herd. Community guardians reduce the risk to both livestock and people posed by several predator species. Several well-documented econometric phenomena may also be

contributing to high value estimates: using WTA rather than WTP, the endowment effect (Kahneman et al., 1991, Thaler, 1980), loss aversion (Plott and Zeiler, 2005), and extreme values associated with risk of death (Jongejan et al., 2005). Additionally it is likely that these estimates suffer from an upward bias due to participants displaying exaggerated preferences for these two programs to signal the desirability of these initiatives as the choice experiment was carried out by the same organisation that provides these services. These estimates therefore cannot be considered accurate estimates of the economic value of mobile bomas and community guardians, but nonetheless provides useful information on the distribution of preferences of one relative to the other. More accurate estimates could be derived by carrying out separate choice experiments for the mobile bomas and community guardians. This could incorporate different levels of several attributes of the mobile boma and community guardians, rather than just yes/no (which refers to presence/absence of mobile bomas and community guardians). If the mobile bomas and community guardians were described by several attributes, such as the amount of protection they offered to livestock, how much protection they offered for human safety and how much of a contribution was made to maize yields, then these effects could be differentiated.

I present two methodological improvements of which I encourage wider use in the environmental economic valuation field. First, I demonstrate the distorting effect of distrust in compensation institutions when estimating WTA using choice experiments. Estimates of WTA for increases in the lion population were 40% lower when only analysing individuals with high levels of trust in compensation schemes. This is a methodological issue likely arising from discounting compensation payments due to distrust, rather than revealing a difference in the costs experienced by lions. Second, I demonstrate calculation of WTP with a conservation outcome as the currency: number of lions that people are willing to accept in return for receiving mobile bomas or community guardians. I argue that this is a directly applicable and easily interpretable metric for conservation practitioners as it measures WTP in the outcome of interest.

The purpose of the economic values derived from the choice experiments and from the wellbeing method discussed below, is not to suggest precise WTP/WTA, or to suggest that monetary compensation schemes constitute a wise solution to HWC. Their purpose is to show the magnitude of rarely measured costs (beyond the value of livestock losses), and to establish their relationship with key covariates.

### 6.1.3. Lions and the wellbeing of the people who live alongside them

Results from Chapter 5 provides evidence that lion presence is associated with statistically detectable negative trends in the wellbeing of the communities in the Mabale area. Having experienced loss of livestock to lions and fear of lions were both associated with lower levels of wellbeing to a similar degree. The effect sizes of these two variables were among the lowest of the significant variables in the regression model, but are nonetheless appreciable. The marginal rate of substitution of having lost livestock and increase in wealth was US$5800 annually for a person of median wealth, and the impact of moving from the lowest to the highest fear level was the same. As I used the log of wealth to account for the diminishing marginal utility of money, the economic value estimates are lower for a person of lower wealth and higher for a person of higher wealth. For a person with income at the 25th percentile, that value was US$2900 and for a person at the 75th percentile, the value was US$13000. However, these figures cannot be used in isolation to gauge the magnitude of the impact of experiencing livestock loss. They must be interpreted in the context of the impact of wealth on wellbeing. Wealth is not associated with large changes in wellbeing after controlling for health, education and other variables, so therefore wealth has to increase a substantial amount to equal the impact of experiencing livestock loss or fear of lions, especially since the impact of those variables was relatively low. Financial instruments aimed at offsetting the negative impacts of carnivore presence are therefore unlikely to be able to offset the negative effects as the amounts of money required with be very difficult to raise for conservation purposes, all other things being equal.

There were also some positive trends in wellbeing linked to the conservation presence in the area. Higher levels of perceived benefits accruing to the household were linked to higher levels of wellbeing, with an effect size comparable to that of education and health.

The results of this study only quantifies the association between lions and wellbeing. There are several other species of wildlife that have an impact on the livelihoods and safety of the inhabitants of the Mabale area: leopards, hyaenas and elephants occasionally enter the village areas. The total impact on wellbeing associated with the maintenance of wildlife populations within Hwange National Park is therefore almost certainly substantially greater than the figures estimated by my regression models, which mainly relate to lions. Experiencing other wildlife-related harm ssuch as crop raiding does not appear to influence wellbeing in the area, as this was included as an explanatory variable in the wellbeing regression and was not significant. This variable included harmful behaviour from all species, including baboons, cattle and quelea birds, most of which do not pose threats to human life (unlike elephants and buffaloes). So an explanation for the lack of association between the crop raiding variable and wellbeing could be that, just as revealed by the attitude analysis and the choice models, the value of the livestock/crops lost is not the largest cause of distress, but rather the threat to human life. Thereby the effect of crop raiding by elephants and buffaloes on people's safety may be undetectable among the noise caused by the smaller species that are included in the same variable. This hypothesis could be tested by including a variable pertaining only to crop raiding by elephants and buffaloes in a wellbeing regression model.

There was no evidence that personally knowing someone who has been attacked by lion was associated with lower wellbeing. However, this does not necessarily mean that living in an environment where you know there have been attacks on people by lions does not affect wellbeing. This is because almost all participants had heard of someone who had been attacked (near 100%), so the effect of the variable pertaining to personally knowing someone who has been attacked (43% of people personally knew someone who had been attacked) is relative to that baseline. Note that the variable describing whether the participant had heard of someone who had been attacked was not part of the model as it contained so little variation. This could mean that the effect on wellbeing of hearing about attacks is sufficiently great that personally knowing someone who has been attacked does not cause further reduction in wellbeing. It is not possible to isolate the effect of stories of attacks based on this data set, but running a wellbeing regression with a variable describing whether respondents had heard of any attacks on humans in a study location with greater variation in the proportion of people who have heard of such attacks could elucidate this.

## 6.2. Implications for conservation practice

### 6.2.1. The influence of intangible factors

All the methods used in this thesis are observational and cannot conclusively determine causality, but causal relationships are fairly likely due to the large number of control variables, and due to the consistency of results between methods. The results from Chapters 3-5 show that non-material (intangible) factors are very likely to be influential on the social dynamics surrounding HWC. Such intangible factors include characteristics of people (e.g. their values), their experiences (e.g. the frequency of seeing lions), and the perceived cost and benefits. The importance of intangible factors are evident in the results from the attitude analysis, in terms of the large number of intangible

variables that emerge as significant in the model, but most importantly the large effect sizes of some intangible variables (ecocentricity and fear). The magnitude of intangible costs as part of people's evaluation of the total costs of lion presence was indicatedby the discrepancy between the total cost estimate derived in the choice experiment and the statistics on the market value of depredated livestock in the Mabale area. The estimated total disvalue of the marginal lion was 817 times larger than the estimate of average expected livestock losses from an additional lion. However, this only reveals the discrepancy between the perceived disvalue of lions and the objective losses from lion predation. It is not possible to say how much of this discrepancy is due to intangible costs and how much is due to the way participants think about likely losses, or to the difference between perceived risk and objective risk (as discussed in section 4.5.1). More reliable evidence for the importance of intangible factors come from the wellbeing regression model, as this is based on a statistical relationship as opposed to participant estimate of risk and losses. Fear of lions had a similar association with wellbeing scores as having experienced tangible livestock losses. Though fear of lions did not display a high effect size compared to other significant variables in the wellbeing model, it did have a large enough effect to be statistically detectable where many other variables one would expect to affect wellbeing did not, such as marital status and worry about crime (for a comprehensive overview of expected relationships and supporting references, see Table 1 in Chapter 5). It is clear that the magnitude of the effects of intangible factors should not be underestimated.

Not only should greater importance be attached to intangible factors, but the range of intangible variables that are considered in studies of HWC should be expanded. For example, ecocentric value-orientation emerged as influential: it was in the highest tier of effect sizes in the attitude analysis, and was associated with preferences towards both lion numbers and compensation payments in the choice models. Yet, it is a metric very rarely included in social surveys on HWC. There may be many more such influential variables that were not included in my analyses, and exploration of this might

substantially improve both the understanding of likely causal relationships and the construction of reliable predictive models. Examples of such variables would be aspects of the other components of the Theory of Planned Behaviour framework, such as social norms and behavioural control (Ajzen, 1985, Fishbein and Ajzen, 2011). This can in turn lead to improved conservation practice. For example, the knowledge that ecocentric values appear to be influential on attitudes and preferences informs conservation practitioners of the importance of not undermining local pro-environmental values and to carefully consider whether material incentives for conservation behaviours may replace intrinsic motivations with extrinsic motivations (Sansone and Harackiewicz, 2000). Due to the comprehensive nature of this survey, it was not possible to examine the same concepts with multiple questions without excessive imposition on the time of the participants, and running the risk of survey fatigue. Therefore, I mostly used single-question indicators. This approach does not yield as nuanced information on the individual variables as would be obtainable if investigating each variable in greater detail, as is the case in for example studies devoted primarily to the study of ecocentricity (e.g Fremantle (2020)) or studies of wildlife value orientation that utilise multiple wildlife belief dimensions (Fulton et al., 1996, Vaske et al., 2011, Deruiter, 2002) . A follow-up investigation devoted to this topic in isolation would greatly improve our understanding of the ecocentricity variable.

The understanding gained by these insights is not specific to conflicts involving lions, nor indeed to conflicts involving carnivores. These findings entail useful lessons for a wide range of contexts involving potentially dangerous species of wildlife. For example, in the case of crop raiding elephants in India, the threat to human life and thus the influence of fear, is plausibly as influential on attitudes as is the case in human-lion conflicts (Rohini et al., 2018). Furthermore, some of the intangible variables that were revealed to be influential are not necessarily specific to species of wildlife that pose a potential threat to human life. I hypothesize that ecocentricity may be as influential on the

tolerance of a wide range of harms, such as crop losses due to ungulates or depredation of livestock by carnivores that do not pose a threat to humans, such as wolverines in Scandinavia.

### 6.2.2. Evaluation of the primacy of material factors

The results of Chapters 3-5 shows the importance of intangible factors in understanding the relationship between humans and wildlife. However, it is not possible to conclude whether material or intangible variables are the most influential, because any such conclusion based on the number of significant variables or effect sizes will be heavily influenced by the initial choice of variables. It is, however, possible to conclude that there is no evidence in these models for favouring socio-demographic and economic variables (which is the dominant status quo) over variables pertaining to beliefs, perceptions, past experiences and emotions. The highest performing attitude model was the comprehensive model that incorporated both types of variables, and the variables with the highest effect size were composed of a mixture of tangible and intangible variables. The choice models found associations with intangible (ecocentricity, fear and trust) variables. Both tangible (experience of livestock loss) and intangible (fear) aspects of lion presence influenced the wellbeing of the people in Mabale, as well as a variable with a mixture of tangible and intangible benefits (benefits arising from the national park). However, despite including the tangible variables that are conventionally thought to be key to HWC (wealth, livestock loss and various metrics of risk to livestock predation (whether respondents owned any livestock, how many livestock they owned, how dependent they were on livestock for income and total wealth)), materials factors did not dominate any of the analyses, and none of them exceeded fear in terms of their effect size in regards to attitudes. So either my intangible variables are related to some latent tangible variable that I did not measure, or intangible variables are somewhat more influential. It is not possible to conclude with certainty, and since an undiscovered latent construct is always a theoretical possibility, it will probably never be possible to do so.

Variables that relate to observable characteristics (such as gender or age) do have a series of advantages: they are unlikely to suffer from endogeneity bias and a range of psychological biases, and some are less likely to suffer from reporting bias and recall bias (but this does not apply to all such variables, some such as wealth, are susceptible to reporting bias). For the practitioner it is just important not to assume that any relationships with the response variable are causal. Many of the observable variables that appeared to have a significant relationship with attitude to coexistence with lions when analysed separately in the socio-economic thematic model became insignificant when controlling for other types of variables. Practitioners cannot even assume that models of observable tangible variables provide the best predictive model, as the thematic model relating to beliefs and values outperformed the socio-economic model for predictive purposes. Models such as the management model presented in chapter 3 do not provide the best predictive model, however this was a pragmatic model based on what variables can actually be observed with a minimum of costs, i.e. not require the organisation of a large questionnaire survey. These findings are consistent with the conclusions of extensive meta-analysis by Kansky and Knight (2014), who found that commonly used socio-demographic variables poorly explained attitudes and that tangible costs and benefits were 2-3 times more non-significant than significant.

### 6.2.3. Livestock loss

Due to the importance assigned to livestock loss in the academic literature and in the discourse with village communities around Hwange National Park, I investigated a wide range of variables related to livestock. I investigated livestock loss at different levels and different indicators of risk and vulnerability to livestock loss.

Metrics of livestock loss at the personal level emerged as influential in both the analysis of attitudes and wellbeing. The number of livestock lost in the last 3 years was among the three variables with the highest effect sizes in the comprehensive attitude model, and there was strong evidence for an

association between having experienced livestock loss and lower levels of wellbeing. However, there was no evidence for a relationship between the total number of livestock killed or injured in the village area between 2008 and 2019 and attitude or wellbeing, indicating that personal losses are the more likely drivers of changes in attitudes and wellbeing. Notably, the number of livestock lost emerged as a significant variable in the attitude analysis while only whether the respondent had ever lost livestock was significant in the wellbeing analysis. This difference reveals that the psychological relationship between livestock loss and an individual's evaluation of how they feel about lions does not behave in the same way as the influence of lion presence on overall quality of life. In the latter case, livestock loss behaves as a binary categorical variable, as would be expected of a traumatic event, rather than as a linear effect that intensifies in proportion to the numbers of losses (Wilker et al., 2015). The effect of numbers of livestock lost on attitude is consistent with the main body of results reported in the literature. Mitchell et al. (2019) found attitudes to lions to be proportional to their involvement in livestock predation and Bhattarai and Fischer (2014), Gebresenbet et al. (2018b), Sarker and Røskaft (2011), Tessema et al. (2010), Lagendijk and Gusset (2008) and Dickman et al. (2014) found that attitudes to large carnivores were related to livestock losses. However, Broekhuis et al. (2018) and Porfirio et al. (2016) found that attitudes to large carnivores were not related to the costs of livestock loss.

I included several indicators of vulnerability and risk in order to investigate which would be most influential on attitudes to coexisting with lions. My aim was to find indications of whether risk or vulnerability is most influential, and whether this relationship operates in a binary or proportional manner. The variables that pertained to risk of livestock loss (i.e. likelihood of suffering losses) were whether respondents owned any livestock and how many livestock they owned. The variables indicating vulnerability (i.e. the consequences of livestock loss) were the degree of dependence on livestock for income and total wealth. None of the indicators of risk or vulnerability showed any association with attitudes to coexistence with lions. Either people's attitudes towards lions are not

influenced by risk and vulnerability, I did not measure the right indicators, or there might be a mis-match between attitudes and underlying beliefs (Fishbein and Ajzen, 2011, Manfredo and Dayer, 2004). Other studies find mixed results: Koziarski et al. (2016) did not find an effect of livestock ownership, while Tessema et al. (2010) found that owning fewer livestock was associated with more positive attitudes. The analysis of wellbeing provides some additional information. There was no evidence for an association between the degree of dependence on livestock for income and wellbeing levels, but owning livestock was associated with higher wellbeing, and overall wealth was associated with higher levels of wellbeing. Wealth is likely to be related to far too many unmeasured covariates that affect wellbeing to be able to make robust inference of the degree to which vulnerability to livestock losses contributes to the positive effect on wellbeing.. The numbers of livestock lost to lion depredation emerged as a useful predictor in the predictive model of observable variables (the management model).

I formed the novel hypothesis that lack of ownership of household wealth would be linked to less negative attitudes towards lions, because an individual might discount possible losses to lions in proportion to the benefits they would actually be able to access from the value of the livestock. However, I did not find evidence for that hypothesis.

### 6.2.4. Economic valuation methods for improved conservation practice

The choice experiment provided a useful estimate of WTP for increases in lion populations, and revealed the discrepancy between perceived total value of lion presence and the value of livestock loss. Economic valuation appears a practicable and useful technique for estimating the costs of wildlife presence. Valuation of conservation programmes however, may be less accurate as I suspect that reporting bias inflated my estimates of the values of the mobile bomas and community guardians despite undertaking every best-practice precaution to minimise strategic responses (employing independent numerators would unfortunately not eliminate strategic responses as

under the ethical guidelines for social scientific research, we were obliged to state the affiliation of the organisers of the research and the purpose of the research, so the role of the TKPP had to be made clear to participants regardless). The choice experiment approach may not be useful when the provider of a conservation initiative is the same entity carrying out the experiments. Economic valuation through wellbeing regressions however does not suffer from strategic reporting bias to the same degree (as stated earlier in the thesis, the aspect of wellbeing investigated in this thesis is subjective wellbeing measured through self-assessed life satisfaction, therefore, that is what the term "wellbeing" refers to throughout). As the relationship between the variables of interest and wellbeing is inferred statistically it is much more difficult to deliberately bias responses, so this technique may be more useful in contexts where conservation practitioners are studying topics where respondents have strong incentives to influence the outcome of the survey. However, the interpretation of the economic values derived from wellbeing regressions differ from those derived from choice experiments. Choice experiments are based on deliberate trade-offs of attributes of choice scenarios by respondents and therefore provide easily interpretable estimates of how much compensation the participants would require to accept a scenario with increases in the wildlife population of interest. Economic estimates based on wellbeing regressions on the other hand show how much a person's wealth would have to increase to offset the effects of wildlife presence on wellbeing. The individuals themselves may not be aware of where that equivalence threshold lies and therefore this does not translate easily into a compensation or benefits-sharing program. What both valuation methods have in common however, is that they are both significant improvements on estimating the harms people experience only in terms of livestock losses and the monetary costs of livestock protection behaviours, which does not account for any intangible costs and benefits and will therefore almost certainly be underestimates.

This discussion pertains to the best way to use economic valuation methods when desirable to do so, it does not claim that economic valuation will be a suitable tool in every situation. Advocating for

conservation based on economic rationalism is not the most appropriate strategy in many situations, instead aesthetic and ethical arguments of the sort that originally inspired the conservation movement may be more effective (Jepson and Canney, 2003). Economic incentives may even be detrimental to achieving conservation aims through crowding out intrinsic motivations for conservation behaviours (Rode et al., 2015).

## 6.3. Strategies for mitigating conflict

### 6.3.1. Fear

These findings have implications for conservation practice when aiming to mitigate HWC. Fear proved to be a recurring variable which affected attitude towards coexistence with lions, preferences in the choice models and life satisfaction in the wellbeing regression model. Despite fear likely being an influential factor in a wide range of situations where people live alongside megafauna, there is not yet consensus on effective mitigation strategies. A review of strategies for targeting fear of large carnivores by Johansson et al. (2016) found evidence on strategies for targeting fear of large carnivores to be scarce and contradictory. In the absence of conclusive evidence for best practices in dealing with high levels of fear of carnivores, suggestions would be to A) Reduce the levels of fear through education, in order to avoid fear levels that are out of proportion to the risk posed by lions (a large portion of the respondents over-estimate the frequency with which lions enter village lands. 36% of respondents thought lions enter village lands every month or more , when the frequency revealed by GPS collar data indicates a frequency of a few times of year). B) Most importantly, reduce the need to be fearful (though the fear of lions may be disproportionate, it is not unfounded as there have been casualties and injuries). TKPP is already engaged in two such programs: the community guardians, and to some extent the mobile bomas, reduce the need to be fearful of lions and other large carnivores. I found that participation in these programs was associated with more positive attitudes to coexisting with lions, however I do not

know whether fear levels are also lower, and not whether this improvement in attitudes translates into behaviour (specifically, reduction in the killing of lions). Further analysis is required to investigate the determinants of fear of lions, and additional field work should be undertaken in the Mabale area to study the relationship between attitudes and actualised behaviours.

### 6.3.2. Disaggregating heterogeneity within communities

Our choice models also show the importance of disaggregating heterogeneity within communities. There has been a tendency within the conservation field to treat communities as homogenous entities (Hemson et al., 2009, Agrawal and Gibson, 1999), but significant heterogeneity may exist, even in preferences where the researchers have strong *a priori* expectations. I expected people to be negative to increases in lion numbers and to have positive preferences towards monetary payments, but the latent class models revealed sub-groups within the population that diverged from these expectations. Without mapping the preferences that exist within a population, conservation interventions may be poorly designed, and produce unexpected consequences (Perry et al., 2020).

### 6.3.3. Strategies for off-setting wellbeing impacts of wildlife presence

Compensation schemes are fraught with difficulties, ranging from limited funds, corruption, strategic behaviour and perverse incentive structures, so they are frequently unsuccessful and inadvisable (Nyhus et al., 2003, Bulte and Rondeau, 2005, Maclennan et al., 2009). At the same time, there is a growing call within the conservation field for increased benefits to local communities (Morgera and Tsioumani, 2010, Blackburn et al., 2016, Jonas et al., 2010, Robinson, 2014). The general efficacy of compensation and benefits-sharing initiatives in promoting pro-conservation behaviour and ensuring equitable treatment of communities is outside the scope of this thesis. However, I will discuss the magnitude of economic values required should conservation practitioners decide to do so.

Our results indicate that the cost of livestock loss constitutes only a small part of the total costs perceived by neighbouring communities and compensating solely on this basis would thus be ineffective in mitigating conflict. However, compensating for the full costs experienced in association with the presence of lions would entail substantial cost and would be likely be impossible with limited conservation funds (the choice experiment and the wellbeing regression estimated compensation to the amounts of US$180 and US$5800 respectively, per person annually). Practitioners would also have to rethink who they provide compensation for – traditional compensation schemes compensate livestock owners experiencing losses, but the intangible harms of carnivore presence are not limited to people who own livestock. This greatly increases the scope and cost of compensation schemes.

Whether to use the economic value estimate from the choice experiment (estimated compensation amount of US$180) or from the wellbeing regression (estimated compensation amount of US$5800) depends on the aim of the intervention. If the aim is to provide enough benefits to compensate for the costs that people perceive arising from increases in the lion population, then the results from the choice experiment would be appropriate. If the aim is to have no net negative effect on people's wellbeing from maintaining lion populations, then the figure from the wellbeing regression would be the appropriate value. However, a cheaper way to approach this problem would probably be to reduce the number of people who experience the trauma of livestock predation in the first place. Subjective wellbeing has extensive support from both observational studies and experimental studies as well as physiological data and has been shown to be a robust measure of wellbeing (see section 6.2.2.). Both these estimates are, of course, specific to the communities in which the research took place. However, they provide insight into the magnitude of costs that are likely in similar contexts.

If the aim is to offset externalities of wildlife presence suffered by communities, then wellbeing may be improved more cost-effectively by providing healthcare and education rather than financial

benefits. This depends on the cost of improving healthcare and education in the location in question. Of course, education and healthcare are among the things people are most likely to spend money on if their financial position improves, but they are not likely to be the only things people will spend money on, and the happiness model shows that, when controlling for health and education, wealth entails a very small improvement in wellbeing per dollar. Therefore, direct investment in health and education may give greater wellbeing improvements per dollar. This approach is appropriate if the motivation is to offset the negative effects of wildlife presence for normative and ethical reasons. However, if the aim is to achieve conservation goals, then there needs to be clear link between benefits received by communities and conservation outcomes (Stem et al., 2003, Smith, 2014).

Looking at the results of the attitude analysis and the wellbeing regression in conjunction offers a promising pathway for offsetting any harms caused by wildlife presence among communities living near protected areas. The degree to which people perceived that their household benefits from the presence of the national park was associated with both higher wellbeing scores and more positive attitudes to lions. However, only 31% of participants perceived there to be any benefits to their household from the national park. There therefore appears to be substantial room for improvements in benefits-sharing, and the link between the benefits received and conservation outcomes would be clear. This could potentially be achieved by reforming the benefits-sharing mechanisms of the CAMPFIRE program, or through the creating of new programmes that provided benefits to communities based on existence value of wildlife. Programmes based on payments for existence value could be linked to the value derived by the global public by being funded by NGOs that receive international donations.

### 6.3.4. Community guardians and mobile bomas

The TKPP employs local men and women as community guardians and provides mobile bomas with the aim of encouraging tolerance of lions and protecting communities. The results of Chapter 3 and

4 provides insights into the relationship between these conservation initiatives and attitudes to co-existence with lions, and the extent to which these services are valued by the communities.

People who were protected by community guardians were more positive than people who were not covered by either programme, while people who received both community guardians and mobile bomas were the most positive. Furthermore, this was one of the variables with the largest effect size, indicating that these conflict mitigation programs have a substantial effect on attitudes. The effect was of comparable size to the effect of the number of livestock lost. Whether that in turn translates to changes in behaviour is not covered by my study. However, both guardians and mobile bomas have been shown to be effective in preventing the killing of lions and loss of livestock in other locations (Hazzah et al., 2014, Sutton et al., 2017). For participation in the mobile bomas programme, a selection effect where people who are more positive to lions are more likely to participate cannot be ruled out. However, the locations for the community guardians programme were selected purely based on location and the level of conflict of that area (for which control variables are included in the model) so there was no scope for self-selection with regards to the community guardians. The positive association between participating in these programmes and attitudes is consistent with the findings of Sibanda et al. (2020) in the Hwange area.

The results of the choice experiments (Chapter 4) showed positive preferences for both community guardians and mobile bomas. Though our estimates are not sufficiently precise to provide an exact economic value, it is clear that both mobile bomas and community guardians are highly valued, so the communities appreciate these programmes. The latent class model shows that different sub-groups in the population value the two programmes to different degrees. However, the community guardians emerge as the most valued when estimating a choice model for all the participants as a whole.

All in all, the mobile boma and community guardian programmes are associated with more positive attitudes (though causality cannot be proven), and participants in the choice experiment attach high values to these programmes, and all sub-groups in the population are positive towards these programs. These findings support the continued use of these programs in the Hwange area, and suggests that similar programs could be useful in similar contexts in Africa and elsewhere.

## 6.4. Limitations of this research

### 6.4.1. Philosophical framework, assumptions and criticisms of the life satisfaction (LS) approach

Bond and Lang (2019) argue that much of the research on life satisfaction is embedded within a neo-utilitarian framework which takes the position of maximisation of an individualistic social welfare function. However, this recent paper's claim has not yet been debated in the literature and the link between wellbeing research and neo-utilitarianism is not unequivocal. Wellbeing research is an interdisciplinary field belonging to economics, humanities and other social sciences. Within the wider topic of wellbeing, the quantitative investigation of LS usually falls within the field of economics. It provides a departure from the standard economic model and the assumptions of rationality. It focuses on the overall satisfaction of the individual rather than the utility derived from consumption of market goods (Baujard, 2013). It is an empirical literature, focused on econometrically determining the determinants of LS and provide information to policy-makers beyond conventional economic indicators (Baujard, 2013).

The LS method receives criticisms on normative and methodological grounds. The main methodological issues fall into four categories.

i. Recall bias: The LS approach entails asking participants to make an assessment of their life, which is partially a judgement of the present and partially an assessment of the past. Memory suffers from a range of experimentally demonstrated biases. People have been found to place most emphasis on the peak and the tail end of an experience (Treasury, 2011).

ii. Context effects: When assessing their wellbeing, individuals tend to base the assessment on the information that is the most accessible at the time. This is in turn determined by how recently and frequently the information has been used (Schwarz and Strack, 1999), meaning that the survey process itself can influence the outcome of LS questions as the preceding questions may have made certain information more accessible (Bertrand and Mullainathan, 2001). However, these effects are unlikely to apply to questions that pertain to issues that are already prominent in the mind of the respondent (Treasury, 2011). Factors that affect the mood of the respondent can also give rise to context effects: events such as finding a dime, spending time in a pleasant room, watching a football team win and sunny weather have been found to influence self-assessed LS (Schwarz and Strack, 1999). Though current mood should in principle not affect the assessments of one's overall life, it may lead to selective retrieval of positive/negative information, or be used as an heuristic indicator of one's life in general (Treasury, 2011).

iii. Reporting bias: Respondents may adjust their responses to give more socially acceptable self-evaluations. LS scores are higher in face-to-face surveys than in phone surveys and characteristics of the interviewer can also influence responses (Treasury, 2011).

iv. Cross-country comparisons: Comparisons of LS between countries is fraught with difficulty as the wording of the question in different languages may hold different associations and respondents may be measuring their LS in relation to drastically different baselines (Baujard, 2013).

Critics also raise a number of normative concerns:

i. Adaptation: People have the capacity to adapt to detrimental circumstances and may score highly on LS questions despite low scores on objective indicators of wellbeing, which can lead to under-prioritisation of disadvantaged groups in policymaking (Dolan and Metcalfe, 2012). From the perspective of human-wildlife conflict, this can lead to acceptance of high levels of physical or psychological costs to local communities.
ii. Responsibility: Some argue that LS is an individual's concern and lies outsides the responsibilities of government (Baujard, 2013).
iii. Interpersonal comparability: Notions and experiences of wellbeing may be individually variable to the extent that interpersonal comparisons are invalid (Treasury, 2011).

These normative and methodological limitations lead Davoine (2009) to conclude that the economics of wellbeing is necessary but not sufficient alone as a guideline for public action.

### 6.4.2. Evidence on the validity of LS approaches

Despite these objections, there is ample evidence that supports the use of LS as a measure of wellbeing. Several authors find context and mood effects to be limited (!!! INVALID CITATION !!! (Pavot and Diener, 1993, Eid and Diener, 2004, Fujita and Diener, 2005, Diener et al., 2002)). There is also robust evidence for correlation between LS scores and observable indicators of wellbeing: there is a strong correlation between behaviours such as smiling and self-assessed wellbeing (Sandvik et al., 2009), even when using only Duchenne smiles (Duchenne smiles involves the pars laterali muscle, which distinguishes forced smiles from genuine enjoyment) as the indicator (Ekman et al., 1990). Further physiological evidence for the relationship between LS scores and wellbeing comes from correlation with activity in the left pre-frontal cortex of the brain (which is active under conditions of positive emotions). Wellbeing ratings are also robust predictors of strokes (Huppert, 2006), cognitive function (Llewellyn et al., 2008) and recovery from disease (Cohen et al., 2003).

If LS ratings are accurate self-evaluations of a person's life over a longer time scale, as opposed to being shaped by mood and/or biases of the moment the question is asked, stability over time would be expected. Krueger and Schkade (2008) finds correlation between LS questions elicited two weeks apartto be r = 0.59 and concludes that LS responses are sufficiently stable to be useful to inform policymaking.

The evidence suggests that interpersonal comparisons are valid. Stutzer and Frey (2003) and Van Praag (1994) show that people translate verbal labels (such as "good" and "very good") into very similar numeric scores. Sandvik et al. (2009) finds evidence that SWB is comparable between individuals by showing that people are able to both recognise and predict the satisfaction of other individuals, and Kahneman (1997) argues that convergence in interpersonal ratings of pleasure and pain further supports the validity of subjective methods (Treasury, 2011). This strong evidence base for the validity of LS approaches support the choice of this methodology over alternative ways of studying wellbeing.

### 6.4.3. Improvements to survey questions

Number of dependants emerged as influential on attitudes towards coexisting with lions in a surprising way. The *a priori* expectation was that larger numbers of dependants would be associated with a higher degree of vulnerability to both the financial impact of living alongside lions and risk to the personal safety of vulnerable people. However, the relationship between the number of dependants and attitude to coexistence with lions was positive. If I were to undertake the survey again, I would include questions that probed the relationship between the number of dependents and attitudes to coexistence with lions, in particular to test my hypothesis that it relates to existence and bequest value of lions for children and future generations.

The perceived benefits accruing from the national park emerged as an important variable in several analyses, so it would have been preferable to be able to differentiate between different types of benefits. This would allow for differentiation between tangible and intangible benefits and would allow for more specific management and conservation strategy recommendations. To improve on this, I would have included a multiple-choice question where participants could specify the different types of benefits that they perceived themselves to be receiving from the presence of the national park, with a follow-up question for each category where the participant rates how important they perceive that benefit to be on an ordinal scale.

I did not include a specific question about the perceived benefits of CAMPFIRE in the survey as conversations with TKPP experts and the exploratory qualitative interviews indicated that the benefits were perceived to be almost non-existent. Though Sibanda et al. (2020) provide support for this, in retrospect it would have been better to control for benefits from CAMPFIRE formally in the analysis as a control variable.

Negative preferences for compensation proved a notable feature of the choice modelling (though the number of people falling into the class with a negative preference towards compensation was small). The exploratory qualitative interviews revealed the reasons that people provide to explain such preferences, but the survey used for data collection could be improved by including questions to establish the reasons behind negative preference towards compensation for each individual, in order to be able to estimate the relative importance of each reason within the population. These variables could then be incorporated into the latent class model separately as control variables which might provide a more nuanced view of the dynamics of value.

The value estimate of mobile bomas provides an overall value estimate for the services that bomas provide, but bomas provide value in several different ways: protection from lions, leopards and hyenas, and improvement of crop yields through fertilisation by the manure and urine from the cattle kept within. The analysis does not allow for disentanglement of the relative importance of the different contributions to its value. Improved maize yields have been suggested to be as important as livestock protection for the farmers who participate in the mobile bomas (Loveridge and Hunt, 2016), so it would have been useful to be able to estimate the relative importance of livestock protection and fertilisation in determining the value people attach to mobile bomas. This could be achieved by including different levels of the mobile boma attribute in the choice experiment, where the levels of the attribute differed in the amount of fertiliser generated.

### 6.4.4. Improvements to data collection

Increasing the number of people interviewed would have enabled more detailed analysis of the choice model data. The analysis of the effect of level of trust in compensation on value estimates (WTA) was limited to an upper cut-off level of 8 on the trust scale (a scale from 0 to 10) as the sample size was not sufficient to allow the model to converge when analysing the small sub-sets of data beyond the cut-off level of 8. Therefore, it is not possible to say with certainty exactly how the relationship appears at the highest levels of trust.

### 6.4.5. Econometric improvements

Within the field of economic valuation and choice experiments, the effect of distrust in compensation institutions that I have demonstrated warrants serious attention. Distrust can inflate value estimates by at least 40%, so lack of trust in the payment attribute in the experiment can produce upward bias in valuation estimates. Econometric solutions are required to achieve accurate WTA estimates in contexts of distrust in financial institutions. I presented a simple solution by including a question pertaining to the level of trust in compensation schemes as part of the

questionnaire accompanying choice experiments, and running the analysis on a sub-sample of the data. However, this is a statistically inefficient solution as you lose information from the respondents that are excluded. More efficient econometric solutions would greatly improve the use of choice experiments for estimating WTA in the context of countries with high levels of corruption and a turbulent political history. No such solutions currently exist.

## 6.5. Suggestions for future research

There is a lot of scope for further exploration of the relationship between wellbeing and HWC. There do not appear to be any other quantitative studies of the wellbeing impact of dangerous species of wildlife on local communities. Improved understanding of these dynamics pose both a pragmatic and ethical imperative (Milner-Gulland et al., 2014). Once the impact on wellbeing is established, the concept of payment for ecosystem services (Redford and Adams, 2009) can be extended to the maintenance of megafauna populations with high global existence value. Whether such a global externality equalisations scheme would be possible, and if so how, is not known (Nelson, 2009, Dickman et al., 2011, Zabel and Engel, 2010) so further research would be required.

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I  demonstrate the use of conservation outcomes as the currency of willingness-to-pay (WTP) (estimating WTP in terms of the increase in lion numbers that people would be willing to tolerate in return for mobile bomas and community guardians). This provides an easily interpretable and policy-relevant metric for conservation organisations and can usefully be applied more widely in conservation research.

The three data chapters presented in this thesis cast some light on the importance of intangible harms and benefits for understanding the human dimensions of coexistence with lions, but

represent only an initial exploration of these variables. Each of them individually warrants focused research in order to understand their relationship with attitudes and actualised behaviours towards lions.

SUPPLEMENTARY MATERIALS CHAPTER 3

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COMPREHENSIVE DESCRIPTION OF DATA EXPLORATION AND ASSUMPTION TESTING

**Further details on survey design and data collection**

No foreign researchers were present at interviews after the initial training process was complete in order to minimise bias in the responses. To prevent any bias that might arise from being interviewed by a person connected to the respondent's social circle, none of the interviewers had close ties to the villages in Mabale. Villages were approached after receiving permission from both the regional chief and the village head of each village.

Each participant was approached by one person from the interview team who introduced themselves, the wider research project and the collaborating institutions. They explained what the survey was going to be used for, what participation would entail and how the results would be published. The interviewers explained that participation was voluntary and anonymous, and then asked whether the person would consent to participate. Questions covered a range of topics, including socio-economic attributes, values, beliefs and the person's past experiences with lions, depredation and conservation.

**Assumption testing:**

Ordinal response models improve on previous treatment of ordinally scaled responses as continuous (Torra et al., 2006). Testing the fit of ordinal models has until recently been problematical. Recent

work has shown that 'surrogate' residuals can be used for this (Liu and Zhang, 2018, Greenwell et al., 2018). We used the 'R 'sure package (Greenwell et al., 2018), which extract these residuals and provides appropriate diagnostic plots. We considered polynomial effects greater than second order (quadratic) to have no a priori plausibility. Non-significant quadratic terms were not retained.

We tested the proportional odds assumption of ordinal models both graphically and statistically. There is emerging consensus that the graphical tests are better, as statistical tests can pick up on even small discrepancies when analysing data with large sample sizes (Christensen, 2015), such as the data set in this study. We tested the assumption by comparing pairs of models with a likelihood ratio test where the PO odds assumption was relaxed in one of the pair by using the 'nominal' option. We used the clmm2 package for this (counter-intuitively the clmm2 package is earlier) as the clmm package does not currently allow for random effects models to be compared in this way (Christensen, pers. comm.). The graphical method was carried out as outlined by Liu & Zhang 2018 (Liu and Zhang, 2018). Neither the graphical methods nor the statistical test revealed any problematic breaches of the proportional odds assumption.

TABLES

Table S1. Hypotheses supporting the selection of variables

| Variable | Hypothesised relationship to response variable | Supporting references |
|---|---|---|
| "How do you feel about having lions in your area?" | This is the response variable | |
| Name of village | This is used as a random variable to control for site-specific variation | |
| Gender | Females expected to be more negative, due to higher levels of perceived vulnerability and fear. | Suryawanshi et al. (2014), Bhattarai and Fischer (2014), Campbell and Lancaster (2010), Fort et al. (2018), Gebresenbet et al. (2018b) |
| "What is your mother tongue?" (indicator of ethnicity) | Ethnicities expected to differ in their level of agreement with response variable | Hill (2004) |
| How old are you? | Negative relationship with response variable, due to increased vulnerability in old age and due to older people having had a longer time period to accumulate negative experiences and stories about lion conflict. | Suryawanshi et al. (2014), Røskaft et al. (2007), Campbell and Lancaster (2010), Zimmermann et al. (2005), McKay et al. (2018) |
| "Do you or anyone in your household work for Hwange National Park or The Hwange Lion Project?" | Positive relationship with response variable. Receiving income from wildlife-related activities are hypothesised to improve attitude towards lion presence. | Hemson et al. (2009), Sillero-Zubiri and Laurenson (2001) |
| "To what degree do you feel that your household benefits from the presence of Hwange National Park?" | Positive relationship with response variable. Receiving benefits from wildlife-related activities are hypothesised to improve attitude towards lion presence. | Sillero-Zubiri and Laurenson (2001), Broekhuis et al. (2018), Matseketsa et al. (2018), McKay et al. (2018), Tessema et al. (2010) |
| "To what degree does fear of lions interfere with your daily activities? (such as going to school, fetching water, going to visit friends or relatives, or other activities)" | Negative relationship with response variable, due to psychological stress and opportunity costs. | Marchini and Macdonald (2012), Lagendijk and Gusset (2008), Dickman (2010) |

| | | |
|---|---|---|
| “Have you ever seen a lion before, if so how many times?” | Negative relationship with response variable. Increased exposure to lions is hypothesised to increase perceived risk. | Struebig et al. (2018), Kansky and Knight (2014) |
| “How many livestock have you lost to lions in the last 3 years?” | Negative relationship with response variable. Increased tangible losses to lions is hypothesised to increase negativity to the presence of lions. The 3 year period was established as the longest that participants could accurately remember in the piloting process. | Tessema et al. (2010), Gebresenbet et al. (2018b), Bhattarai and Fischer (2014), Holmern et al. (2007), Marchini and Macdonald (2018) |
| “Have you ever lost livestock to lions?” | Negative relationship with response variable. Increased tangible losses to lions is hypothesised to increase negativity to the presence of lions. It is not known what time scale is most influential on attitudes, so this variable and the above were recorded. | Tessema et al. (2010), Gebresenbet et al. (2018b), Bhattarai and Fischer (2014), Holmern et al. (2007), Marchini and Macdonald (2018) |
| “How often do you think lions come onto your village lands?” | Negative relationship with response variable. Increased perceived risk of encounters of lions for people and livestock was hypothesised to increase negativity to lions presence. | Inskip et al. (2014), Naughton-Treves and Treves (2005) |
| “Do you know personally anyone who has been attacked by a lion?” | Negative relationship with response variable. Personally knowing victims of lion attack is hypothesised to create resentment towards lions and increase perceived risk. | Naughton-Treves and Treves (2005), Sillero-Zubiri et al. (2007) |
| “What is your level of education?” | Positive relationship with response variable. Education level is hypothesised to be associated with positive attitudes. | Carter et al. (2014), McKay et al. (2018) de Pinho et al. (2014), Gebresenbet et al. (2018b), Romanach et al. (2007), Romanach et al. (2007), Fort et al. (2018), Suryawanshi et al. (2014), Romanach et al. (2007) |

| | | |
|---|---|---|
| "How many children or elderly people who are past working age, or sick/disabled people who cannot work do you provide for?" | Negative relationship with response variable. Number of dependants was hypothesised to lead to more negative attitudes to carnivores because of increased vulnerability to economic losses and higher vulnerability to attack on humans. | Bjerke et al. (2001), Zinn and Pierce (2002) |
| "To what extent do you agree with the following statement: lions have the right to exist" | Positive relationship with response variable. This indicator of ecocentric value orientation towards lions was hypothesised to increase positivity to lion presence. | Teel et al. (2010), Manfredo and Dayer (2004) Bjerke and Kaltenborn (1999) |
| "How often do you attend church or other religious ceremonies?" | Negative relationship with response variable. Religiosity, particularly in regards to Christian beliefs, was hypothesised to be associated with more negative attitudes to lion presence. | de Pinho et al. (2014), Hazzah et al. (2009) |
| "How important do you think traditional ceremonies (such as rainmaking, ukuthethela and traditional memorial ceremonies) are for the wellbeing of your community?" | Positive relationship with response variable. Adherence to traditional pre-Christian beliefs was hypothesised to be associated with more positive attitudes to lion presence. | Struebig et al. (2018), McKay et al. (2018), (1995) |
| Total wealth (individual's wealth from all sources; livestock, crops, employment and informal work) | Positive relationship with response variable. Hypothesised to be associated with more positive attitudes as wealth increases the ability to absorb losses incurred due to lion presence. | Naughton-Treves and Treves (2005), Zimmermann et al. (2005), Sarker and Røskaft (2011) |
| Number of livestock owned, excluding poultry | Negative relationship with response variable. Owning greater number of livestock may increase the probability of loss or possible magnitude of loss. | Parker et al. (2014) |
| "Do you or anyone in your household own livestock (cattle, goats, poultry and so on)?" | Negative relationship with response variable. This was included in addition to the variable above as it was not known whether people's risk perception is | Parker et al. (2014) |

| | | |
|---|---|---|
| | sensitive to numbers or operate on a more categoric basis. | |
| Proportion of wealth derived from non-animal sources | Positive relationship with response variable. Less dependence on livestock is hypothesised to be associated with more positive attitudes to lion presence due to lower vulnerability of damage to the individual's livelihood. | Holmern et al. (2007), Suryawanshi et al. (2014), Romanach et al. (2007), Tessema et al. (2010) |
| Whether have bomas, guardians, both or neither | Positive relationship with response variable. The purpose of providing mobile bomas and community guardians is to achieve an assumed positive effect on attitudes towards coexisting with lions by reducing livestock losses. | Included to test the effect of the Hwange Lion Project's intervention |
| "How satisfied are you with your current standard of living (material circumstances)?" | Positive relationship with response variable. Wealth has been shown to be related to attitude to carnivores. Work within the field of economics has shown that sometimes the level of satisfaction with own wealth is more influential on people's attitudes as absolute wealth is sensitive to shifting baselines. | Naughton-Treves and Treves (2005) |
| No one else is responsible for lion depredation | Positive relationship with response variable. If the risk and losses associated with lions are perceived to be externally imposed, it may be resented to a greater extent. | Dickman (2010), Skogen et al. (2013) |
| Proportion of life spent in Hwange | Positive relationship with response variable. Being embedded within communities that have co-existed with lions in the area for a long time and have knowledge about how to live alongside them might to lead to less negative attitudes, so immigrants were hypothesised to be more negative. | Røskaft et al. (2003), Hariohay et al. (2018) |

| | | |
|---|---|---|
| Total number of livestock killed or injured in the village area between 2008 and 2019 | Negative relationship with response variable. This variable was included because attitudes may be shaped by the conflict level experienced in the community, rather than losses incurred to the individual household. | Kideghesho et al. (2007), Sillero-Zubiri et al. (2007) |
| Experienced crop raiding (by elephants, baboons, quelea birds, bush pigs or similar) | Negative relationship with response variable. We hypothesise that there is a spill-over effect where losses caused by other wildlife leads to a more negative attitude to conflict-prone wildlife in general. | Our hypothesis |
| In your household, who makes most decisions on how money is spent? | Negative relationship with response variable. If material losses are a main driver of negative attitudes towards lion presence, we hypothesise that individuals with greater ownership of wealth will have more negative attitudes. | Our hypothesis |
| How do you feel your wealth compares with the rest of your village? | Positive relationship with response variable. Work within the field of economics has shown that sometimes perceived relative wealth is more influential on people's attitudes than absolute wealth. | Luttmer (2005) |

Table S2. Variance Inflation Factors for the comprehensive model. Variance Inflation Factors above the value 10 indicate a serious collinearity problem (Lin, 2008).

| Variable | Variance Inflation Factor | Degrees of freedom |
|---|---|---|
| Gender | 1.54 | 1 |
| Ethnicity | 1.67 | 3 |
| Age | 1.96 | 1 |
| Owns livestock | 1.33 | 1 |
| Number of livestock lost | 1.28 | 1 |
| Education | 1.88 | 3 |
| Physical condition | 2.88 | 10 |
| Total wealth | 2.03 | 1 |
| Number of livestock owned | 2.23 | 1 |
| Proportion of non-animal wealth | 2.02 | 1 |
| Satisfaction with material circumstances | 2.76 | 10 |
| Perceived relative wealth | 1.88 | 4 |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | 1.32 | 1 |
| Employment in wildlife work | 1.15 | 1 |
| Ownership of wealth | 1.63 | 2 |
| Number of dependants | 1.21 | 1 |
| Proportion of life spent in Hwange | 1.18 | 1 |
| Programme participation | 1.56 | 2 |
| Frequency of seeing lions | 1.62 | 3 |
| Personally know someone attacked by lion | 1.23 | 1 |
| Experienced other wildlife-related harm | 1.14 | 1 |
| Perceived household benefits from national park | 1.50 | 4 |
| Fear | 1.74 | 4 |

| | | |
|---|---|---|
| Ecocentricity | 1.41 | 4 |
| Religiousness | 1.69 | 5 |
| Belief in traditional religion | 1.49 | 4 |
| Nobody is responsible for losses to lions | 1.11 | 1 |
| Perceived frequency of lions entering village lands | 1.87 | 4 |

Table S3. Variance Inflation Factors for the management model

| Variable | Variance Inflation Factor | Degrees of freedom |
|---|---|---|
| Gender Female | 1.02 | 1 |
| Ethnicity | 1.12 | 3 |
| Age | 1.03 | 1 |
| Programme participation | 1.27 | 2 |
| Number of livestock lost | 1.03 | 1 |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | 1.16 | 1 |

Table S4. Variance Inflation Factors (VIF) for the socio-economic model

| Variable | Variance Inflation Factor | Degrees of freedom |
|---|---|---|
| Gender | 1.17 | 1 |
| Ethnicity | 1.25 | 3 |
| Age | 1.80 | 1 |
| Education | 1.65 | 3 |
| Owns livestock | 1.26 | 1 |
| Number of livestock lost | 1.11 | 1 |
| Physical condition | 1.94 | 10 |
| Total wealth ^2 | 2.10 | 2 |
| Number of livestock owned | 2.16 | 1 |
| Proportion of non-animal wealth | 1.99 | 1 |
| Satisfaction with material circumstances | 1.62 | 10 |
| Employment in wildlife work | 1.07 | 1 |
| Ownership of wealth | 1.47 | 2 |
| Number of dependants | 1.15 | 1 |

Table S5. Variance Inflation Factors for the beliefs and perceptions model

| Variable | Variance Inflation Factor | Degrees of freedom |
|---|---|---|
| Fear | 1.31 | 4 |
| Econcentricity | 1.12 | 4 |
| Religiousness | 1.12 | 5 |
| Belief in traditional religion | 1.13 | 4 |
| Nobody is responsible for losses to lions | 1.05 | 1 |
| Perceived frequency of lions entering village lands | 1.24 | 4 |

Table S6. Variance Inflation Factors for the past experiences with wildlife and conservation model

| Variable | Variance Inflation Factor | Degrees of freedom |
|---|---|---|
| Proportion of life spent in Hwange | 1.05 | 1 |
| Programme participation | 1.23 | 2 |
| Frequency of seeing lions | 1.14 | 3 |
| Personally know someone attacked by lion | 1.10 | 1 |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | 1.17 | 1 |
| Experienced other wildlife-related harm | 1.04 | 1 |
| Number of livestock lost | 1.10 | 1 |

Table S7. Coefficients, standard error (SE) and p-values of the management model. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| Variable | Estimate | SE | P-value | * |
|---|---|---|---|---|
| Gender Female (reference level: “male”) | -0.16 | 0.10 | 0.13 | |
| Ethnicity Nambya (reference level: “Ndebele”) | 0.19 | 0.16 | 0.23 | |
| Ethnicity Tonga | -0.49 | 0.18 | 0.01 | * |
| Ethnicity other | 0.11 | 0.23 | 0.62 | |
| Age | -0.01 | <0.001 | <0.001 | *** |
| Programme participation: only guardians (reference level: “Both guardians and bomas”) | -0.41 | 0.26 | 0.12 | |
| Programme participation: neither guardians or bomas (reference level: “Both guardians and bomas”) | -0.93 | 0.30 | <0.001 | ** |
| Number of livestock lost | -0.07 | 0.01 | <0.001 | *** |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | <0.001 | <0.001 | 0.87 | |

Table S8. Coefficients, standard error (SE) and p-values of the socio-economic model. “.” Indicates very low significance level (0.1), “*” indicates low level (0.05), “**” indicates intermediate level (0.01), and “***” indicates high significance level (0.001).

| Variable | Estimate | SE | P-value | * |
|---|---|---|---|---|
| Gender Female (reference level: “male”) | -0.32 | 0.11 | <0.01 | ** |
| Ethnicity Nambya (reference level: “Ndebele”) | 0.21 | 0.16 | 0.21 | |
| Ethnicity Tonga | -0.56 | 0.19 | <0.01 | ** |
| Ethnicity other | 0.19 | 0.24 | 0.42 | |
| Age | -0.02 | <0.001 | <0.001 | *** |
| Education | -0.32 | 0.21 | 0.13 | |
| Owns livestock (reference level: “does not own livestock”) | -0.26 | 0.22 | 0.24 | |
| Number of livestock lost | -0.06 | 0.01 | <0.001 | *** |
| Physical condition | -0.25 | 0.20 | 0.21 | |

| | | | | |
|---|---|---|---|---|
| Total wealth | -2.76 | 2.65 | 0.30 | |
| Total wealth ^2 | 4.20 | 2.04 | 0.04 | * |
| Number of livestock owned | 0.03 | 0.02 | 0.24 | |
| Proportion of non-animal wealth | 0.52 | 0.26 | 0.04 | * |
| Satisfaction with material circumstances^2 | 0.35 | 0.15 | 0.02 | * |
| Employment in wildlife work (reference level: "not employed in wildlife work") | -0.19 | 0.13 | 0.16 | |
| No ownership of wealth (reference level: "full ownership of wealth) | 0.13 | 0.15 | 0.40 | |
| Partial ownership of wealth | -0.05 | 0.14 | 0.71 | |
| Number of dependants | 0.05 | 0.03 | 0.05 | . |

Table S9. Coefficients, standard error (SE) and p-values of the beliefs and perceptions model. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| Variable | Estimate | SE | P-value | * |
|---|---|---|---|---|
| Fear | -1.52 | 0.13 | <0.001 | *** |
| Ecocentricity | 0.82 | 0.19 | <0.001 | *** |
| Religiousness | -0.18 | 0.14 | 0.19 | |
| Belief in traditional religion | 0.17 | 0.11 | 0.10 | |
| Nobody is responsible for losses to lions (reference level: "someone else is responsible for losses to lions") | 0.27 | 0.11 | 0.02 | * |
| Perceived frequency of lions entering village lands | -0.84 | 0.20 | <0.001 | *** |

Table S10. Coefficients, standard error (SE) and p-values of the past experiences with wildlife and conservation model. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| Variable | Estimate | SE | P-value | * |
|---|---|---|---|---|
| Proportion of life spent in Hwange | -0.35 | 0.15 | 0.02 | * |
| Programme participation: only guardians (reference level: "Both guardians and bomas") | -0.55 | 0.27 | 0.04 | * |
| Programme participation: neither guardians or bomas (reference level: "Both guardians and bomas") | -1.21 | 0.30 | <0.001 | *** |
| Frequency of seeing lions | -0.17 | 0.10 | 0.10 | . |
| Do not personally know someone who has been attacked by lion (reference level: "personally know someone") | 0.44 | 0.12 | <0.001 | *** |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | <0.001 | <0.001 | 0.95 | |
| Experienced other wildlife-related harm (reference level: "not experienced other wildlife-related harm) | -0.33 | 0.11 | <0.01 | ** |
| Number of livestock lost | -0.05 | 0.01 | <0.001 | *** |

Table S11. Comparison of the comprehensive model, and of the three thematic models with variables pertaining to beliefs and perceptions, socio-economic variables and past experiences. ΔAIC is the difference in Akaike Information Criterion (AIC) between the model in question and the top model.

| Model | Number of parameters (K) | AIC | ΔAIC | AIC weight (ω) | Log likelihood (LL) |
|---|---|---|---|---|---|
| Comprehensive model | 38 | 2938.15 | 0 | 1 | -1431.08 |
| Beliefs and perceptions | 11 | 3212.71 | 274.56 | 0 | -1595.36 |
| Socio-economics | 23 | 3255.42 | 317.26 | 0 | -1604.71 |
| Past experiences | 13 | 3340.83 | 402.68 | 0 | -1657.42 |

| | | | | | |
|---|---|---|---|---|---|
| Management model | 14 | 3356.67 | 418.52 | 0 | -1664.33 |

EFFECT SIZES

**Average effect sizes**

Table S12. Average effect size of explanatory variables across all levels of the response variable (attitude to coexistence with lions) within the socio-economic model. Ordered from highest to lowest. See section 3.4.2. for description of the procedure.

| Explanatory variable | Average effect size |
|---|---|
| Number of livestock lost | 0.15 |
| Total wealth ^2 | 0.15 |
| Proportion of non-animal wealth | 0.15 |
| Satisfaction with material circumstances^2 | 0.15 |
| Age | 0.10 |
| Number of dependants | 0.07 |
| Gender Female | 0.03 |
| Ethnicity | 0.02 |

**Effect sizes of individual variables within the comprehensive model**

Table S13. Effect sizes and associated standard errors (SE) for "gender" within the comprehensive model

| Gender | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Male | 0.73 | 0.15 | 0.06 | 0.04 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| Female | 0.78 | 0.13 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |

Table S14. Effect sizes and associated standard errors (SE) for "ethnicity" within the comprehensive model

| Ethnicity | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Ndebele | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Nambya | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| Tonga | 0.84 | 0.09 | 0.04 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 | 0.00 |
| Other | 0.76 | 0.14 | 0.06 | 0.03 | 0.02 | 0.05 | 0.03 | 0.01 | 0.01 | 0.01 |

Table S15. Effect sizes and associated standard errors (SE) for "age" within the comprehensive model

| Age | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 0.72 | 0.15 | 0.07 | 0.04 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 30 | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 50 | 0.78 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |
| 70 | 0.82 | 0.10 | 0.04 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 | 0.00 |
| 80 | 0.84 | 0.09 | 0.04 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 | 0.00 |

Table S16. Effect sizes and associated standard errors (SE) for “number of livestock lost” within the comprehensive model

| Number of livestock lost | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.75 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 10 | 0.79 | 0.12 | 0.05 | 0.03 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.00 |
| 30 | 0.87 | 0.08 | 0.03 | 0.02 | 0.01 | 0.05 | 0.03 | 0.01 | 0.01 | 0.01 |
| 40 | 0.89 | 0.06 | 0.02 | 0.01 | 0.01 | 0.06 | 0.03 | 0.01 | 0.01 | 0.00 |

Table S17. Effect sizes and associated standard errors (SE) for “education” within the comprehensive model

| Education | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| None | 0.71 | 0.16 | 0.07 | 0.04 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| Primary | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| Secondary | 0.77 | 0.13 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Tertiary | 0.79 | 0.12 | 0.05 | 0.03 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S18. Effect sizes and associated standard errors (SE) for “number of dependants” within the comprehensive model

| Number of dependants | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.79 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |
| 3 | 0.75 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 6 | 0.70 | 0.16 | 0.07 | 0.04 | 0.03 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 10 | 0.65 | 0.18 | 0.08 | 0.05 | 0.03 | 0.06 | 0.03 | 0.02 | 0.01 | 0.01 |
| 13 | 0.60 | 0.20 | 0.10 | 0.06 | 0.04 | 0.08 | 0.03 | 0.03 | 0.02 | 0.02 |

Table S19. Effect sizes and associated standard errors (SE) for "proportion of life spent in Hwange" within the comprehensive model

| Proportion of life spent in Hwange | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.70 | 0.16 | 0.07 | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 0.30 | 0.72 | 0.15 | 0.07 | 0.04 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 0.50 | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 0.80 | 0.77 | 0.13 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| 1.00 | 0.78 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |

Table S20. Effect sizes and associated standard errors (SE) for "Participation in the project's conflict mitigation programmes" within the comprehensive model

| Participation in the project's conflict mitigation programmes | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Boma and guardians | 0.61 | 0.20 | 0.10 | 0.06 | 0.04 | 0.07 | 0.03 | 0.02 | 0.02 | 0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Only guardians | 0.74 | 0.15 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Neither | 0.83 | 0.10 | 0.04 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 | 0.00 |

Table S21. Effect sizes and associated standard errors (SE) for "frequency of seeing lions" within the comprehensive model

| Frequency of seeing lions | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Never | 0.73 | 0.15 | 0.06 | 0.03 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| One time | 0.76 | 0.13 | 0.06 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| A couple of times | 0.78 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |
| Many times | 0.80 | 0.11 | 0.04 | 0.02 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.00 |

Table S22. Effect sizes and associated standard errors (SE) for "personally know someone attacked by lion" within the comprehensive model

| Personally know someone attacked by lion | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Yes | 0.78 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | <0.001 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | 0.74 | 0.15 | 0.06 | 0.03 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S23. Effect sizes and associated standard errors (SE) for "Perceived degree of benefits accruing from the protected area" within the comprehensive model

| Perceived degree of benefits accruing from the protected area | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Don't benefit at all | 0.78 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | <0.001 |
| Benefit a little | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Moderately benefits | 0.70 | 0.16 | 0.07 | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| Benefit strongly | 0.65 | 0.18 | 0.09 | 0.05 | 0.03 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| Very strongly benefits | 0.60 | 0.20 | 0.10 | 0.06 | 0.04 | 0.06 | 0.03 | 0.02 | 0.02 | 0.01 |

Table S24. Effect sizes and associated standard errors (SE) for "interference of fear of lions" within the comprehensive model

| Interference of fear of lions | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Doesn't interfere at all | 0.48 | 0.23 | 0.14 | 0.09 | 0.06 | 0.04 | 0.02 | 0.02 | 0.02 | 0.02 |
| Barely interferes | 0.59 | 0.20 | 0.10 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| Moderately interferes | 0.70 | 0.16 | 0.07 | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| Severely interferes | 0.79 | 0.12 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | <0.001 |
| Very severely interferes | 0.85 | 0.09 | 0.03 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.00 | <0.001 |

Table S25. Effect sizes and associated standard errors (SE) for "ecocentric values regarding lions" within the comprehensive model

| Ecocentric values regarding lions | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Strongly disagree | 0.87 | 0.08 | 0.03 | 0.01 | 0.01 | 0.03 | 0.02 | 0.01 | <0.001 | <0.001 |
| Somewhat disagree | 0.84 | 0.09 | 0.04 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | <0.001 | <0.001 |
| Neither agree nor disagree | 0.80 | 0.11 | 0.04 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | <0.001 |
| Somewhat agree | 0.76 | 0.13 | 0.06 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Strongly agree | 0.71 | 0.16 | 0.07 | 0.04 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S26. Effect sizes and associated standard errors (SE) for "belief in traditional religion" within the comprehensive model

| Belief in traditional religion | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Not important at all | 0.78 | 0.13 | 0.05 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | <0.001 |
| Somewhat important | 0.76 | 0.13 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Moderately important | 0.75 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Very important | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Extremely important | 0.73 | 0.15 | 0.06 | 0.04 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S27. Effect sizes and associated standard errors (SE) for "perceived frequency of lion incursion onto village land" within the comprehensive model

| Perceived frequency of lion incursion onto village land | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Never | 0.70 | 0.16 | 0.07 | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| A few times per year | 0.74 | 0.14 | 0.06 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Every month | 0.77 | 0.13 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | <0.001 |
| Every week | 0.80 | 0.11 | 0.04 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | <0.001 |
| Every day | 0.83 | 0.10 | 0.04 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 | <0.001 |

**Effect sizes for individual variables within the socio-economic model**

Table S28. Effect sizes and associated standard errors (SE) for "gender" within the socio-economic model

| Gender | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Male | 0.59 | 0.20 | 0.10 | 0.06 | 0.04 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| Female | 0.66 | 0.18 | 0.08 | 0.05 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S29. Effect sizes and associated standard errors (SE) for “ethnicity” within the socio-economic model

| Ethnicity | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| Ndebele | 0.62 | 0.19 | 0.09 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| Nambya | 0.57 | 0.21 | 0.11 | 0.07 | 0.05 | 0.05 | 0.02 | 0.02 | 0.02 | 0.01 |
| Tonga | 0.75 | 0.14 | 0.06 | 0.03 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| Other | 0.58 | 0.21 | 0.11 | 0.07 | 0.04 | 0.06 | 0.02 | 0.02 | 0.02 | 0.01 |

Table S30. Effect sizes and associated standard errors (SE) for “age” within the socio-economic model

| Age | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 0.54 | 0.22 | 0.12 | 0.07 | 0.05 | 0.04 | 0.02 | 0.02 | 0.02 | 0.01 |
| 30 | 0.59 | 0.20 | 0.10 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 50 | 0.68 | 0.17 | 0.08 | 0.04 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 0.76 | 0.13 | 0.06 | 0.03 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 80 | 0.79 | 0.12 | 0.05 | 0.03 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S31. Effect sizes and associated standard errors (SE) for "number of livestock lost to lions" within the socio-economic model

| Number of livestock lost to lions | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.60 | 0.20 | 0.10 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 10 | 0.73 | 0.15 | 0.06 | 0.03 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 30 | 0.91 | 0.06 | 0.02 | 0.01 | 0.01 | 0.03 | 0.02 | 0.01 | 0.00 | <0.001 |
| 40 | 0.95 | 0.03 | 0.01 | 0.01 | 0.00 | 0.03 | 0.02 | 0.01 | 0.00 | <0.001 |
| 60 | 0.98 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | <0.001 |

Table S32. Effect sizes and associated standard errors (SE) for "total wealth" within the socio-economic model

| Total wealth^2 (standardised) | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| -0.9 | 0.58 | 0.21 | 0.11 | 0.06 | 0.04 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 1 | 0.67 | 0.18 | 0.08 | 0.05 | 0.03 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 3 | 0.66 | 0.18 | 0.08 | 0.05 | 0.03 | 0.06 | 0.03 | 0.02 | 0.01 | 0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 0.47 | 0.23 | 0.14 | 0.09 | 0.07 | 0.15 | 0.03 | 0.05 | 0.05 | 0.04 |
| 8 | 0.24 | 0.22 | 0.20 | 0.18 | 0.17 | 0.20 | 0.08 | 0.03 | 0.10 | 0.16 |

Table S33. Effect sizes and associated standard errors (SE) for "proportion of non-animal wealth" within the socio-economic model

| Proportion of non-animal wealth | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.02 | 0.70 | 0.16 | 0.07 | 0.04 | 0.03 | 0.05 | 0.02 | 0.01 | 0.01 | 0.01 |
| 0.3 | 0.67 | 0.17 | 0.08 | 0.05 | 0.03 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 0.5 | 0.65 | 0.18 | 0.09 | 0.05 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 0.8 | 0.61 | 0.20 | 0.10 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 1 | 0.59 | 0.20 | 0.10 | 0.06 | 0.04 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S34. Effect sizes and associated standard errors (SE) for "Satisfaction with material circumstances" within the socio-economic model

| Satisfaction with material circumstances ^2 | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 (Extremely dissatisfied) | 0.62 | 0.19 | 0.09 | 0.06 | 0.04 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 1 | 0.62 | 0.19 | 0.09 | 0.05 | 0.04 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 2 | 0.63 | 0.19 | 0.09 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 3 | 0.63 | 0.19 | 0.09 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.63 | 0.19 | 0.09 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 5 | 0.63 | 0.19 | 0.09 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 6 | 0.63 | 0.19 | 0.09 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 7 | 0.63 | 0.19 | 0.09 | 0.05 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 8 | 0.63 | 0.19 | 0.09 | 0.05 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 9 | 0.64 | 0.19 | 0.09 | 0.05 | 0.03 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |
| 10 (Extremely satisfied) | 0.64 | 0.19 | 0.09 | 0.05 | 0.03 | 0.04 | 0.02 | 0.01 | 0.01 | 0.01 |

Table S35. Effect sizes and associated standard errors (SE) for "number of dependants" within the socio-economic model

| Number of dependants | Very negative | Quite negative | Indifferent | Quite positive | Very positive | SE Very negative | SE Quite negative | SE Indifferent | SE Quite positive | SE Very positive |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.66 | 0.18 | 0.08 | 0.05 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 3 | 0.62 | 0.19 | 0.09 | 0.06 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |
| 6 | 0.58 | 0.21 | 0.11 | 0.07 | 0.04 | 0.04 | 0.02 | 0.02 | 0.01 | 0.01 |
| 10 | 0.53 | 0.22 | 0.12 | 0.08 | 0.05 | 0.06 | 0.02 | 0.02 | 0.02 | 0.02 |
| 13 | 0.49 | 0.23 | 0.13 | 0.09 | 0.06 | 0.08 | 0.02 | 0.03 | 0.03 | 0.02 |

## SUPPLEMENTARY MATERIALS CHAPTER 4

### METHODS

RESULTS

Table S1. Estimate, standard error (SE) and significance level of multinomial logit model (MNL) with no interactions. "." Indicates very low significance level (0.1), "*" indicates low level (0.05), "**" indicates intermediate level (0.01), and "***" indicates high significance level (0.001).

| Attribute | Estimate | Standard error | Significance |
|---|---|---|---|
| Compensation (scaled) | 0.26 | 0.02 | *** |
| Decrease in lion numbers | -0.01 | 0.01 | |
| Increase in lion numbers | -0.03 | 0.00 | *** |
| Mobile bomas | 0.69 | 0.03 | *** |
| Community guardians | 0.94 | 0.03 | *** |
| Status quo | -2.02 | 0.09 | *** |

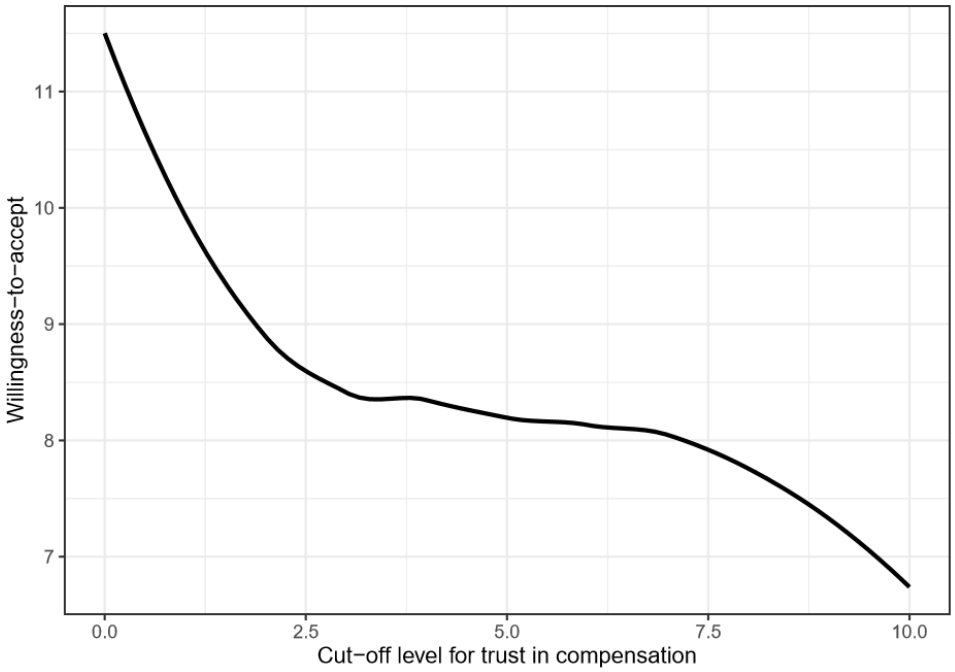



Figure S1. WTA estimates for increases in lion numbers from the MNL model with interaction terms at increasing cut-off levels of trust.

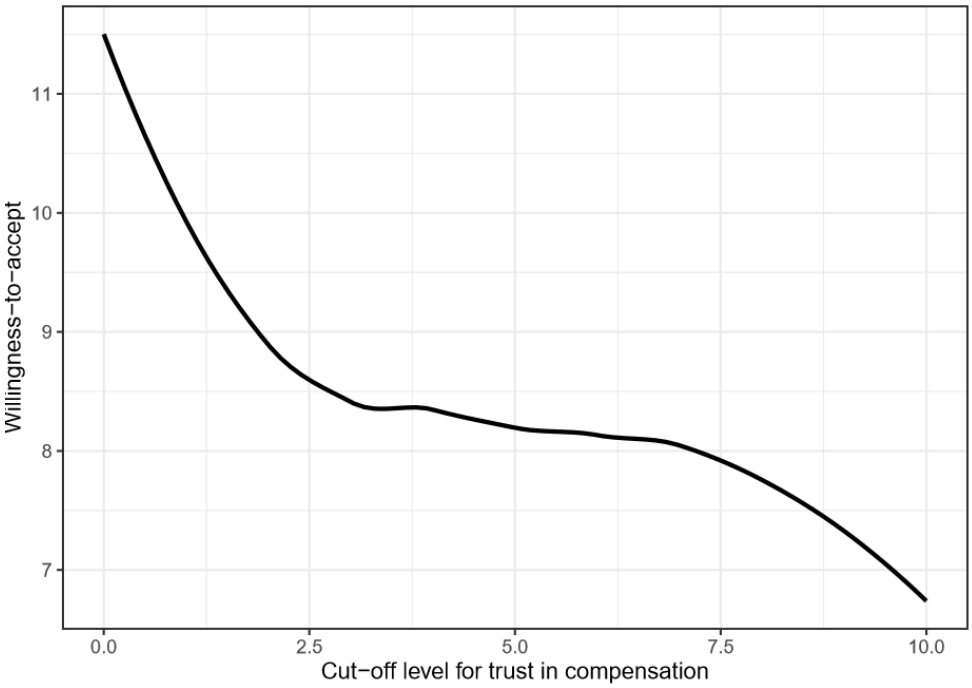



Figure S2. Coefficient for the compensation attribute from the MNL model with interaction terms, at increasing cut-off levels of trust.

SUPPLEMENTARY MATERIALS CHAPTER 5

Table S1. Variance Inflation Factors for the comprehensive model. Variance Inflation Factors above the value 10 indicate a serious collinearity problem (Lin, 2008).

| Variable | Variance Inflation Factor | Degrees of freedom |
|---|---|---|
| Age | 1.43 | 1 |
| Gender | 1.20 | 1 |
| Ethnicity | 1.04 | 3 |
| Perceived household benefits from national park | 1.05 | 4 |
| Fear | 1.11 | 4 |
| Owns livestock | 1.14 | 1 |
| Has ever lost livestock to lions | 1.24 | 1 |
| Do not personally know someone who has been attacked by lion | 1.07 | 1 |
| Education | 1.18 | 3 |
| Physical condition | 1.18 | 10 |
| Religiousness | 1.08 | 10 |
| Proportion of non-animal wealth | 1.15 | 1 |
| Perceived comparative wealth | 1.13 | 4 |
| Nobody is responsible for losses to lions | 1.03 | 1 |
| Proportion of life spent in Hwange | 1.08 | 1 |
| Total number of livestock killed or injured in the village area between 2008 and 2019 | 1.08 | 1 |
| Ownership of wealth | 1.14 | 2 |
| Experienced other wildlife-related harm | 1.13 | 3 |
| Marital status | 1.04 | 3 |
| Frequency of socialisation with friends/family | 1.08 | 6 |
| Helpfulness and support within community | 1.05 | 4 |
| Worry about crime | 1.06 | 4 |
| Participation in organisations and clubs | 1.16 | 1 |
| Wealth | 1.26 | 1 |

| | | |
|---|---|---|
| Number of livestock lost last 3 years | 1.15 | 1 |
| Perceived frequency of lions entering village lands | 1.41 | 4 |

GRAPHS**Effect plots for the significant and marginally significant variables (p < 0.1) in subjective wellbeing model**

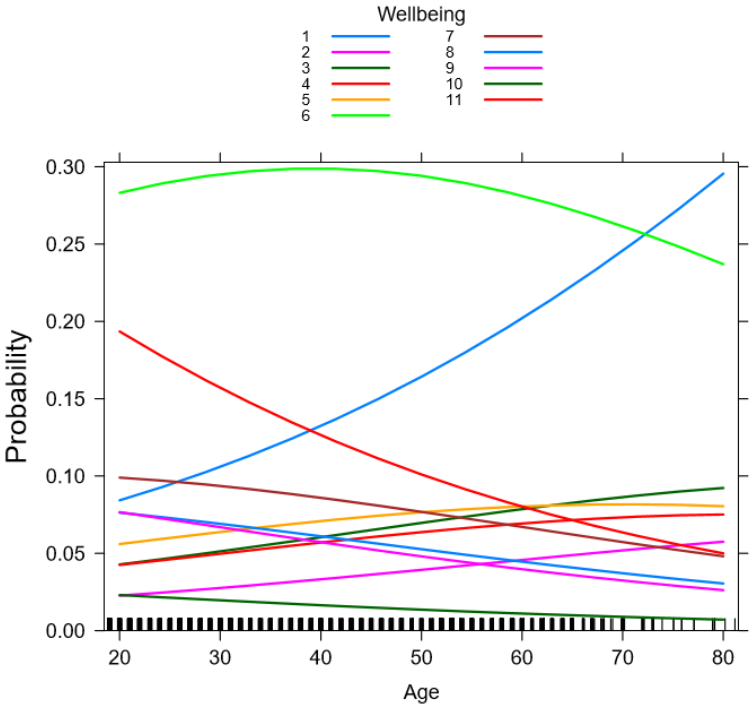



Figure S1. Effect of age. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

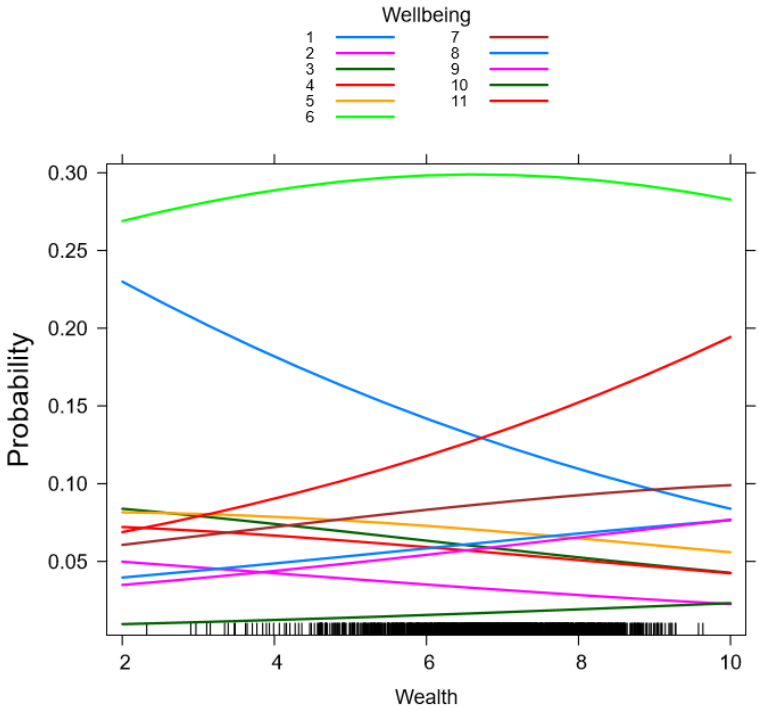


Figure S2. Effect of wealth. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”). On the log scale, 2 corresponds to US$10, 4 to US$50, 6 to US$400, 8 to US$3000 and 10 to US$2200 (rounded up to the nearest ten, hundred or thousand).

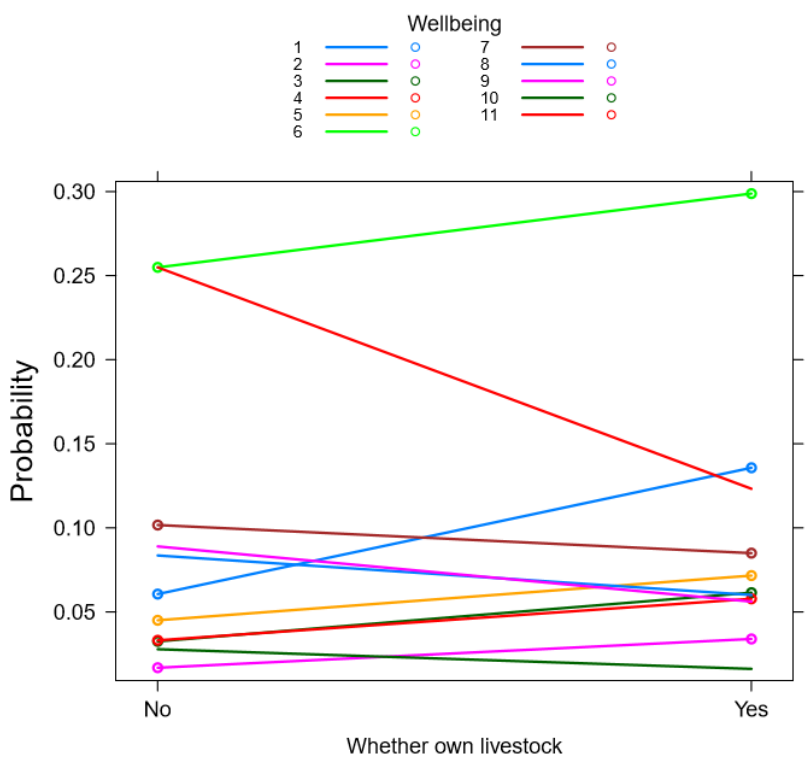



Figure S3. Effect of whether the person owns livestock. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

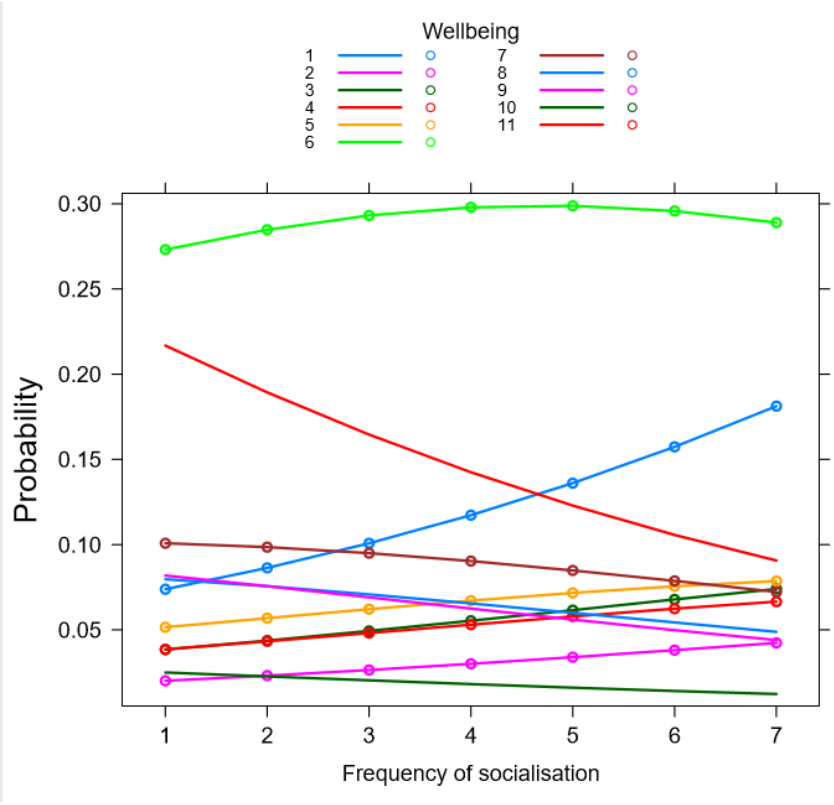



Figure S4. Effect of how frequently the person socialises. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

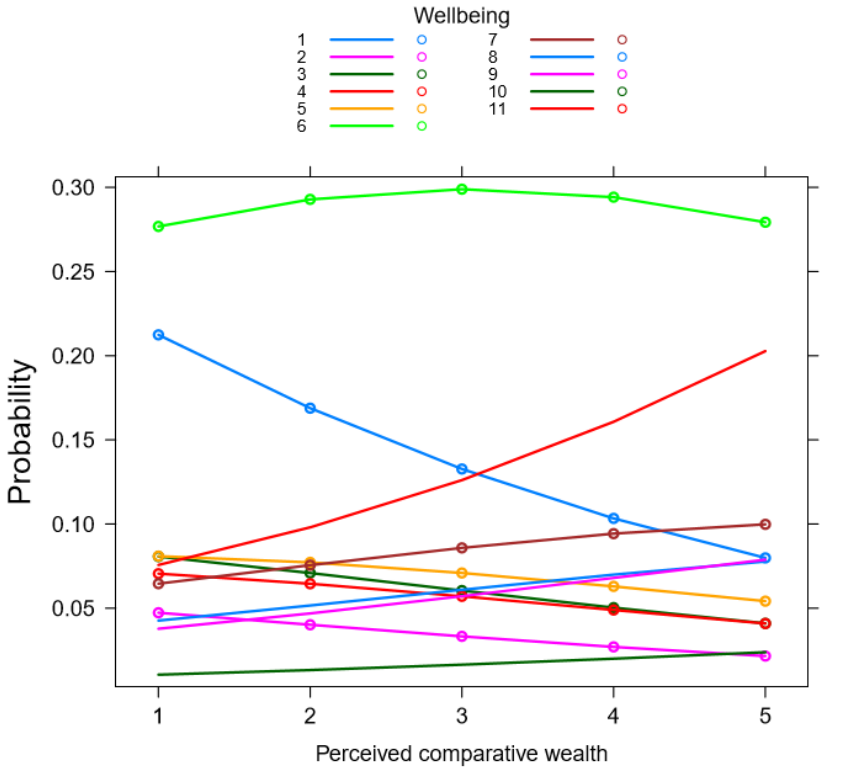



Figure S5. Effect of perceived wealth level compared to the rest of the community. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

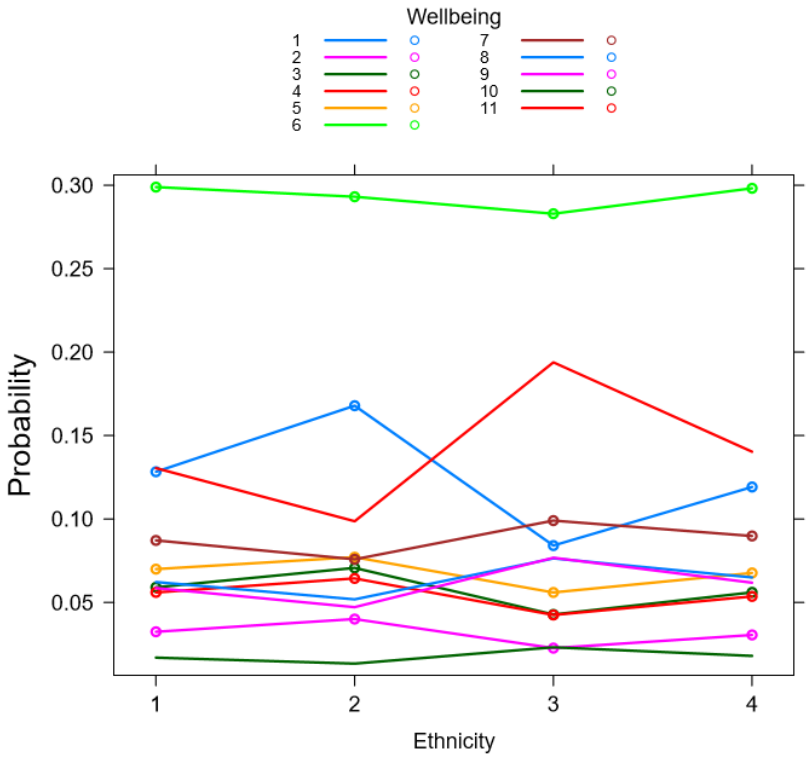



Figure S6. Effect of ethnicity. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”). 1 = Ndebele. 2 = Nambya. 3 = Tonga 4 = Other.

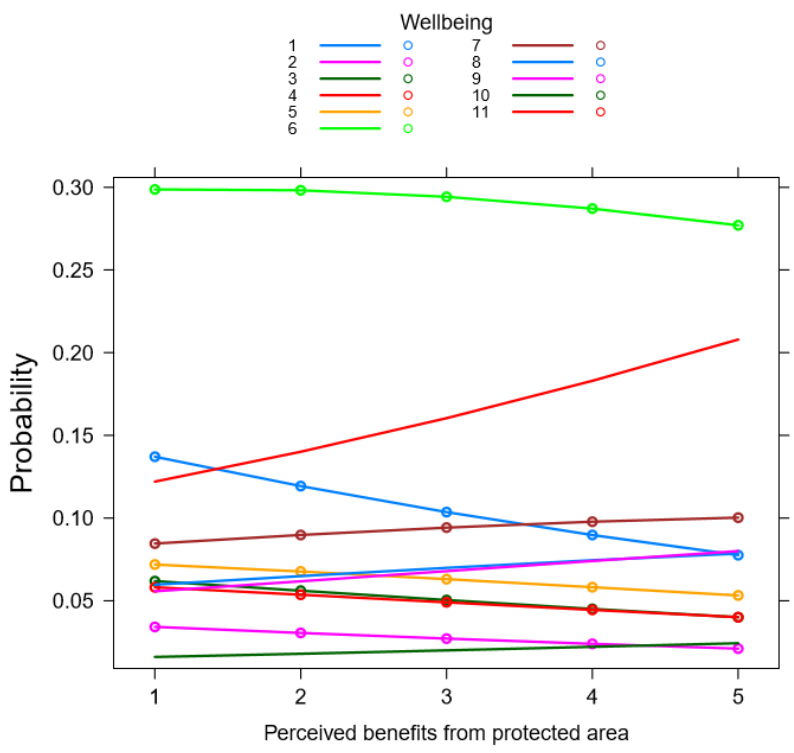



Figure S7. Effect of perceived level of benefits accruing from the protected area. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

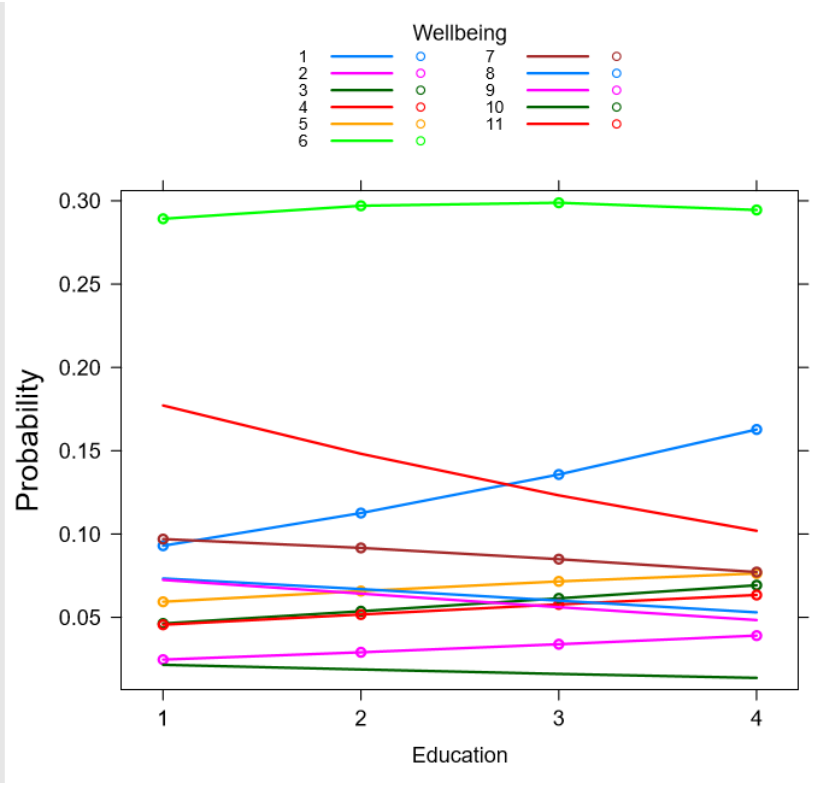



Figure S8. Effect of education. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

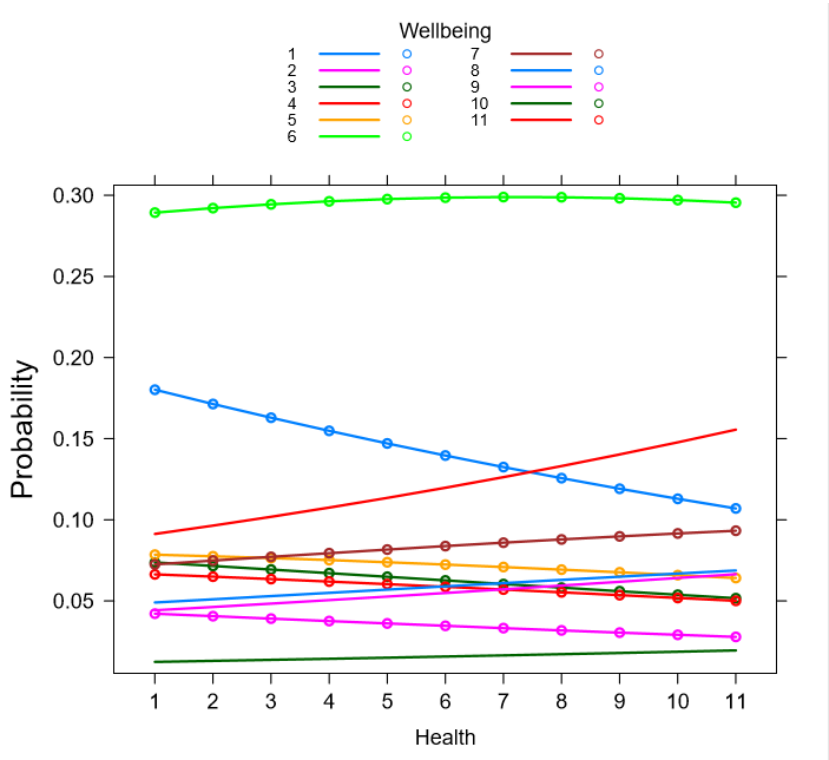



Figure S9. Effect of health. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”).

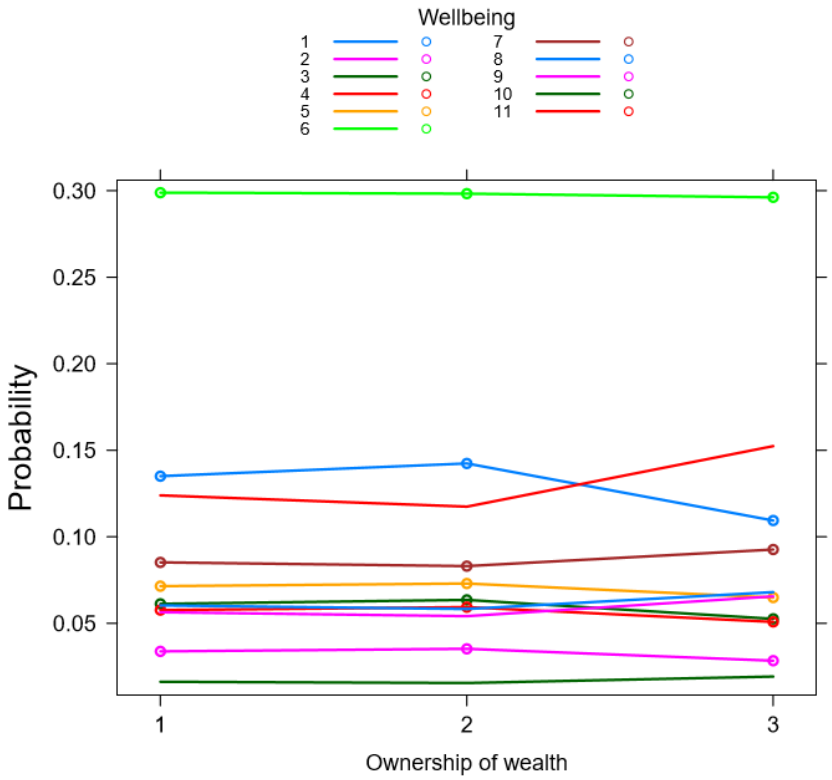



Figure S10. Effect of ownership of wealth within the household. Legend: Wellbeing on a scale from 0 ("Not at all satisfied") to 10 ("Completely satisfied"). 1 = I have the main ownership of wealth. 2 = Someone else has the main ownership of wealth. 3 = Ownership of wealth is equally shared with someone else.

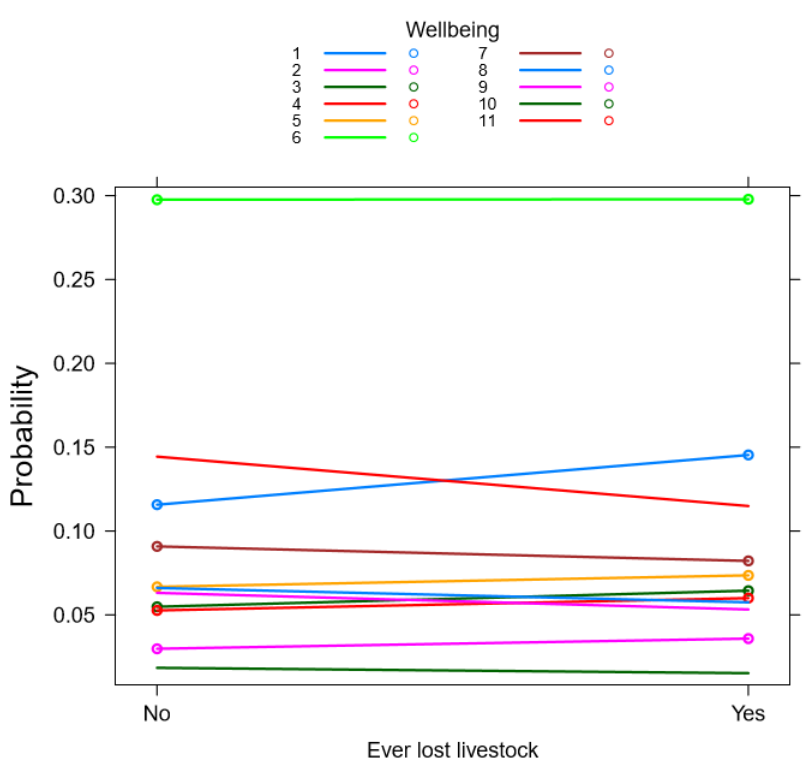



Figure S11. Effect of ever having lost livestock. Legend: Wellbeing on a scale from 0 ("Not at all satisfied") to 10 ("Completely satisfied").

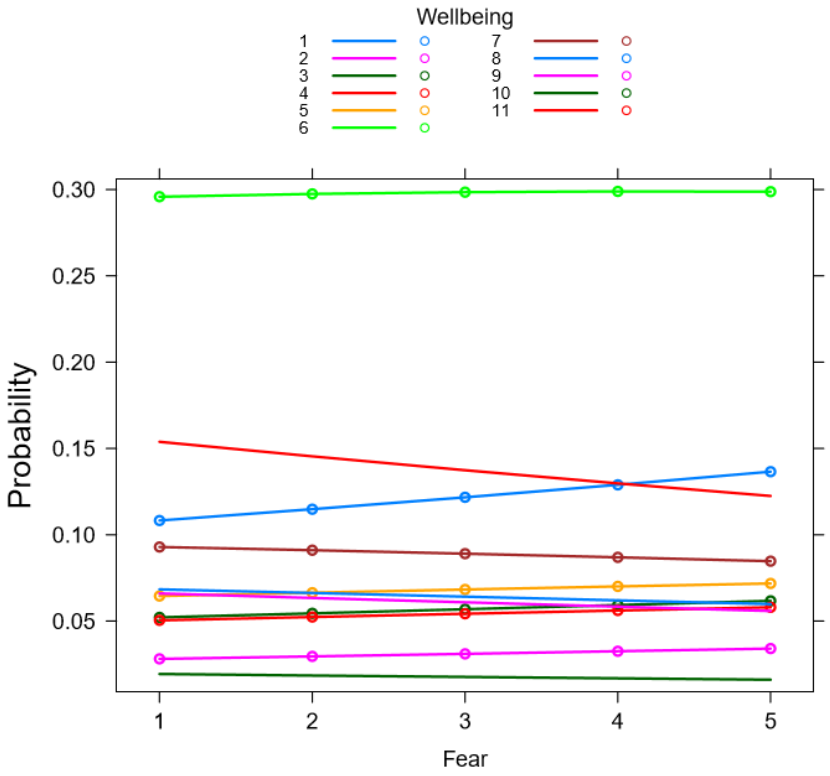



Figure S12. Effect of fear. Legend: Wellbeing on a scale from 0 (“Not at all satisfied”) to 10 (“Completely satisfied”)

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# APPENDIX

Other work produced during my DPhil period:

*Published in peer-reviewed journals*

Trouwborst, A., Blackmore, A., Boitani, L., Bowman, M., Caddell, R., Chapron, G., Cliquet, A., Couzens, E., Epstein, Y., Fernández-Galiano, E., Fleurke, F.M., Gardner, R., Hunter, L., Jacobsen, K., Krofel M., Lewis, M., Lopez-Bao, J. V., Macdonald D.W., Redpath, S., Wandesforde-Smith, G., Linell, J.D., 2017. International wildlife law: understanding and enhancing its role in conservation. BioScience, 67(9), pp.784-790.

Macdonald, D.W., Loveridge, A.J., Dickman, A., Johnson, P.J., Jacobsen, K.S. and Du Preez, B., 2017. Lions, trophy hunting and beyond: knowledge gaps and why they matter. Mammal Review, 47(4), pp.247-253.

Macdonald, D.W., Jacobsen, K.S., Burnham, D., Johnson, P.J. and Loveridge, A.J. 2016. Cecil: A Moment or a Movement? Analysis of Media Coverage of the Death of a Lion, Panthera leo. Animals, 6(5), p.26.

*In progress*

Jacobsen, K.S., and Dhanda, S. In progress. Edible orchids and illegal trade: a review

Shepherd-Cross, J., Tan C.K., Jacobsen K.S. In progress. Farmers' perspective on the reintroduction of lynx to the UK: investigating attitudes and predicting potential culling behaviour.

Dickman, A.J., Loveridge, A., Hinks, A., Jacobsen K. J., Bauer H., Macdonald D. W., In progress. Ecological and socio-political fragility of free-ranging African lion populations.

Pierre, M., Sillero C., Jacobsen K.S. In progress. Conflict with black caiman (Melanosuchus niger) with indigenous communities in southern Guyana

Good C., Jacobsen K.J., Macdonald D.W. In progress. The influence of sports mascot on support for conservation.

*Government reports:*

Macdonald, D.W., Dickman, A., Loveridge, A.J., Jacobsen, K.S., Johnson, P.J., O'Kane, C., du Preez, B. 2016. Report on lion conservation – with particular respect to the issue of trophy hunting. Prepared on the request of Secretary of State of the Environment, DEFRA.