A Wildlife Tolerance Model and Case Study for Understanding Human Wildlife Conflicts

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Abstract

Human-wildlife conflict (HWC) is a complex conservation issue and acknowledging the human dimensions of the problem is critical. Here we propose the Wildlife Tolerance Model (WTM), a novel theoretical framework to identify key drivers of tolerance to living with damage-causing wildlife. The WTM proposes an *outer model,* where the extent to which a person experiences a species determines perceptions of *cost*s relative to *benefits* of living with a species. This in turn determines tolerance. A second component, the *inner model* predicts eleven variables that may further drive perceptions of *costs* and *benefits*. In the current paper we test the *outer model* while in a forthcoming publication we test the *inner model* using a case study of human-baboon conflict in Cape Town, South Africa. Using Partial Least Squares Structural Equation Modeling we found support for the *outer model*. *Experience* explained 30% of variance in *costs* and *benefits* and 60% of *tolerance* was explained by perceptions of *costs* and *benefits*. *Intangible costs* and *intangible benefits* equally contributed to driving *tolerance* but *tangible costs* had no significant effect on *tolerance.* Separating two dimensions of experience, (i) *exposure* to a species explained *costs* more than *benefits*, and (ii) *positive experiences* explained *intangible cost*s and *benefits* more than *tangible costs* while *negative experiences* equally explained *costs* and *benefits*. We discuss management implications of the findings and conclude that the WTM could be a useful diagnostic tool and theoretical framework to inform management interventions and policies to mitigate HWC.

1. Introduction

Mammals are declining worldwide and while habitat loss, habitat degradation and harvesting pose the greatest threat to mammals (IUCN 2008) these factors indirectly promote conflicts. As the declining wildlife habitats become smaller and fragmented, contact between people and wildlife increases. Human-Wildlife Conflict (HWC) is therefore recognized as a global priority (Manfredo 2015) and an emerging research field (Cronin et al. 2014) as it can incur major costs to rural people's livelihoods and lives, as well as reduce support for conservation projects in general (Redpath et al. 2013). Initial research focused on finding technological solutions to mitigate the impacts of wildlife, assuming damage was the main driver of intolerance. However ongoing research revealed that *"the causes of conflict are often complex and deep-seated, and a broader approach must be utilized in order to ameliorate such conflict fully in the long term"* (Dickman 2010). To address this complexity a focus on the human dimensions of wildlife conflicts is increasingly being acknowledged as critical (Decker et al. 2012; Redpath et al. 2013; Manfredo 2015). Human wildlife conflicts can therefore be framed as occurring within Social Ecological Systems (SES) where interactions between ecosystems, biodiversity and people take place (Folke et al. 2004). Framing HWC within SES acknowledges HWC as a complex conservation problem that requires multidisciplinary and trans-disciplinary approaches (Game et al. 2014). We define Human wildlife conflicts (HWC) as a type of biodiversity conflict (Bennett et al. 2001) consisting of two components: (i) impacts that deal with direct interactions between humans and wildlife species (Young et al. 2010); and (ii) conflicts between humans themselves over how to manage the impacts between humans and wildlife.

The human dimensions of wildlife conflicts pose a number of challenges for wildlife managers. Firstly, determining the extent of a conflict and its impact. This is necessary to enable conservation managers to identify if, where and which interventions are needed. To achieve this, understanding diverse viewpoints of stakeholders is necessary. Democracy in wildlife management is increasingly being acknowledged as important to reduce conflict and ensure successful conservation outcomes (Decker et al. 2012; Woodroffe & Redpath 2015). Obtaining a wider range of stakeholder views is particularly important so that those heard are not only the powerful individuals and those with extreme views, or institutions and specialized interest groups that are unrepresentative of stakeholders. Imbalances in stakeholder voices can increase the probability of species management based on non-representative views and may increase unsustainable wildlife practices, if a vocal or powerful minority favor these.

Secondly, what are the factors that determine variation in tolerance? There is sufficient evidence in the HWC literature to conclude that individuals differ widely in their attitudes and tolerance towards wildlife (Kansky et al. 2014). For example, some stakeholders remove wildlife species despite not encountering any problems, while others with problems will not remove species (Marker et al. 2003). Some stakeholders will implement mitigation measures to prevent or reduce damage, while others will not (Maclennan et al. 2009) and some farmers will forgo different numbers of livestock to different species of wildlife (Romanach et al. 2007). Determining the extent of stakeholder tolerance and the factors driving this tolerance is therefore critical (Treves & Bruskotter 2014). To address these questions, quantitative randomized surveys may be best suited to determine the extent of a problem as perceived by communities living in close proximity to damage-causing wildlife and their tolerance towards the wildlife.

Research on stakeholder attitudes to living with wildlife is increasing and aims to understand factors explaining tolerant behavior (Kansky & Knight 2014; Kansky et al. 2014). Individual case studies largely make up this research, and to date few quantitative syntheses of the outcomes of these studies are available (but see Williams et al. 2002, Dressel et al. 2015). Recently, we conducted meta-analyses of attitudes of people living with four groups of damage-causing mammals (carnivores, ungulates, elephants, primates) (Kansky et al. 2014; Kansky & Knight 2014). These analyses identified several globally apparent drivers of tolerant attitudes. In this paper we build on these findings and propose the Wildlife Tolerance Model (WTM). The WTM presents an interdisciplinary theory for application to HWC research and management. It aims to incorporate the complexity inherent in human-wildlife social ecological systems (SES) and be a diagnostic tool to identify key factors driving tolerance of people towards damage-causing mammalian wildlife. This in turn can inform management interventions and policy design. We then test the utility of the WTM using a case study of human-baboon conflict in an urban environment on the Cape Peninsula, South Africa. The WTM consists of two components; an *outer model* with six variables and an *inner model* with 11 variables (Fig 1). In the current paper we describe the WTM and test the *outer model*. In a forthcoming publication (and Kansky 2015) we test the *inner model*.

2. The Wildlife Tolerance Model

2.1 Outer Model

In the *outer model*, experience is the first variable and is operationalized using two variables; (i) recent *Exposure* to a species (ii) number of *Meaningful Experiences* a person has had with the species. *Meaningful Experiences* are strong emotionally charged experiences, which can be either positive (*Positive Meaningful Experience*) or negative (*Negative Meaningful Experience*) and are not time constrained, meaning they could have occurred at any time in a persons life. *Exposure* measures the frequency and spatial proximity a person has been exposed to in a particular time frame. *Benefits* and *Costs* are the next pair of variables. These are separated into *tangible* and *intangible*. *Tangible* refers to the monetary costs and benefits, while *intangible* refers to non-monetary values, such as the existence value of a species or feelings of fear or stress due to a species. The first prediction of the model (H1) is that *experience* drives perceptions of *costs* and *benefits*. So if experiences are more positive than negative, the scale will tilt towards greater perceptions of *benefits*, and vice versa with negative experiences and *costs.* The second hypothesis (H2) is that *cost* and *benefit* perceptions drive tolerance (Fig.1, Table 1).

We define tolerance as "The ability and willingness of an individual to absorb the extra potential or actual costs of living with wildlife" as anyone living in an area with wildlife has to bear the risk of added costs which would not be present in the absence of wildlife. Based on a critical evaluation of seven categories of questions used to elicit tolerant attitudes and perceptions towards damage-causing mammals in a meta-analysis (Kansky & Knight 2014) we identified five tolerance indicators that could be used in surveys: 1. **Spatial** - tolerance to spatial proximity, 2. **Damage** - tolerance to undergoing monetary costs due to a species, 3. **Killing** - tolerance to killing under different contexts, 4. **Population size** - of a species that a person is willing to accept (Carpenter et al. 2000), 5. **Prevention** - ability and willingness to undergo extra costs (tangible and intangible) to apply mitigation measures that are effective, sustainable, legal and comply with welfare norms. These indicators are further discussed in Appendix A.

All variables in the *outer model* were found to be important in our meta-analysis and discussed in detail in Kansky & Knight (2014) and Appendix A. Table 1 presents key hypotheses predicted from the WTM.

2.2 Inner Model

The *inner model* consists of 11 variables predicted to impact on perceptions of *costs* and *benefits*. These are *Wildlife Value Orientations, Anthropomorphism, Interest in* *animals, Taxonomic group, Personal norm, Institutions, Empathy, Values, Norms, Habits, Perceived behavioral Control* (Fig 1). For example, for *Interest in animals*, the prediction is that people who are more interested in animals will perceive relatively more *benefits* than *costs* and therefore be more tolerant than those who dislike animals. And for *Institutions*, individuals who perceive institutions involved in managing a species negatively will perceive more *costs* than *benefits* to living with the species and therefore be less tolerant. Below we elaborate on the *inner model* variables. More detailed discussions are in Appendix A and in Table 1 key hypotheses predicted from the WTM presented.

Interest in Animals is predicted to be important from meta-analysis results (Kansky & Knight 2014) as well as a link to self-identity. When attitudes towards an object are tied to personal identity the attitudes gain strength (Heberlein 2012). Individuals for whom animals are salient may identify themselves as an "animal" person and can be expected to have stronger positive attitudes and tolerance towards wildlife.

Empathy has not been measured in quantitative HWC surveys (Kansky & Knight 2014) but is predicted to be important since high trait empathy predicts pro social behavior towards humans (Konrath et al. 2011) as well as animals (Erlanger & Tsytsarev 2012).

Anthropomorphism - Qualitative HWC studies report attribution of mental capacities and intentions to various wildlife species that affects attitudes and tolerance towards them (Goedeke 2005; Hill & Weber 2010). Negative perceptions result when expectations of human-like social behavior arise that non-human species cannot satisfy (Root –Bernstein et al. 2013). Animals that are perceived to be more similar to humans may be seen as more beneficial and therefore tolerated.

Taxonomic bias - Evidence of the human propensity to value animal species differently is widespread (Kansky et al. 2014; Appendix A). Attributes explaining these differences include similarity to humans in morphology, behavior, natural history traits and phylogeny, as well as attractiveness, utility, size, rarity, danger and cultural symbolism. Understanding these biases and their translation into behavior towards species in HWC is critical as strategies and policies will be needed to mitigate these biases.

Values are important life goals that serve as guiding principles in a person's life (Schwartz et al. 2012). Differences in values are acknowledged as driving conflicts in general and biodiversity conflicts in particular (Heberlein 2012; Madden & McQuinn 2014) but are not examined in quantitative HWC attitude studies (Kansky & Knight 2014). Understanding differences in values are key to designing conservation mitigation interventions (Heberlein 2012) as well as in stakeholder mediation (Madden & McQuinn 2014).

Wildlife value orientations - Expanding on the notion that individuals and groups may have different value "priorities" in relation to wildlife, the wildlife value orientations (WVO) concept was developed (Manfredo 2008). Two main dimensions are recognized; *Utilitarian*'s believe wildlife are primarily for human benefit and support activities resulting in death or harm to wildlife. *Mutualists'* believe wildlife as deserving rights and less likely to support actions resulting in death or harm (Manfredo 2008). WVO predict support for a variety of wildlife management options (Manfredo 2008) and therefore useful to guide policies supported by the public.

Institutions were predicted to be important from meta-analytic review but rarely applied in quantitative surveys (Kansky & Knight 2014). Factors predicted as important drivers of *costs* and *benefits* are: i) laws regulating wildlife use and management ii) number, role and efficacy of organizations, iii) quality of relationships between stakeholders and organizations, iv) Property-rights systems and relation to wildlife ownership.

Personal norms are the rules and expectations one has for oneself that guide behavior. Norm Activation Theory (NAT) (Schwartz & Howard 1998) predicts that pro-social behavior is activated by feelings of moral obligation (guilt) to help in a given situation. Building on this model personal norms are important drivers of pro-environmental behaviors (Klockner 2013). In HWC research personal norms have not been included in quantitative surveys (Kansky & Knight 2014) but are predicted to be important in guiding implementation of mitigation measures and personal responsibility.

Self-efficacy/behavioral control is the belief in one's capabilities to organize and execute actions required to manage situations (Bandura 2012). When operationalized as Perceived Behavioral Control (PBC) it often predicts behavior (Fishbein & Ajzen 2010). It predicts pro environmental behaviors (Klockner 2013) and behaviors important in human wildlife conflicts (Marchini et al. 2012) but is rarely applied in HWC studies (Kansky & Knight 2014). Understanding factors that enable or prevent PBC will be important in design of interventions to assist stakeholders implementing mitigation measures.

Social Norms are the rules and expectations about how group members should behave, and are the building blocks of culture (Taylor et al. 2005). Social norms predict general behavior (Fishbein & Ajzen 2010), pro-environmental behavior (Heberlein 2012; Klockner 2013) and in HWC (Manfredo 2008) but is rarely applied in quantitative HWC surveys (Kansky & Knight 2014). In HWC's we predict three important issues relating to social norms; i) the extent to which social pressure drives stakeholder perceptions of *costs* and *benefits*, ii) the extent to which wildlife norms are being driven by potentially influential individuals, iii) what mitigation measures are considered the norm and the extent to which these result in sustainable wildlife populations and welfare considerations.

Habits are behaviors that develop in response to specific stable contextual cues that are repeated in the same situation because rewards (goals) are achieved by the repetition (Verplanken & Orbell 2003). Habits are important predictors of pro-environmental behavior, i.e. habits can prevent behavior change (Klockner 2013). In HWC habits may prevent the adoption of mitigation measures to prevent damage. For example livestock farmers may have habitual methods of farming which make it difficult to change if HWC's develop. Defining habits that increase costs of living with wildlife and knowledge of their strength will be important to design strategies to reduce them.

The selection of variables for the WTM was based on our meta-analyses in addition to research within a wide range of disciplines that we thought necessary to incorporate the complexity of HWC. For example, all *outer model* variables were found to be important from the meta-analyses (*experience, costs, benefits* and *tolerance*) as well as the *inner model* variable *taxonomic group*. I*nstitutions* came from research on common pool resources and social-ecological systems, *Empathy, Interest in animals* and *Taxonomic group* came from human-animal relations research and *Values*, *Wildlife Value Orientations, Norms*, P*ersonal norm, Habits* and *Perceived Behavioral Control* came from social psychology and pro-environmental behaviour research. *Anthropomorphism* came from religious studies and social psychology.

In Appendix A details of WTM variables are provided and in Table 1 key hypotheses predicted from the WTM are presented.

3. Testing the Outer Model of the Wildlife Tolerance Model – a case study of urban human-baboon conflict in South Africa

3.1 Primates and Humans in Conflict

Many primate species utilize human food, crops or waste to supplement their diet or as their main food source (Gautier & Biquand 1994). Traits enabling exploitation of human-modified landscapes include: semi-terrestrial locomotion; large, complex social groupings; flexible, varied diets; intelligence; manual dexterity and agility; and "outgoing" temperaments (Strum 1994; Knight 1999). Foraging in human-modified landscapes presents primates with potential benefits and costs. Crops offer energetic advantages over many natural foods (Naughton-Treves 1998; El Alami et al. 2012) but can result in increased injury and predation; skewed sex ratios (Hill 2000; Kansky 2002); and increased aggression both towards humans and between primate groups (Hsu & Agoramoorthy 2009; El Alami et al. 2012). Impacts on individual species range from local extinction to ecological and behavioural adaptation (Gautier & Biquand 1994; Estrada et al. 2012). Fifty-seven primate species have been recorded in 38 types of agro-ecosystems, with 49% classified as threatened or near threatened on the IUCN Red List (Estrada et al. 2012). Baboons are among the most successful primates in Africa and occupy all biomes except extreme desert. Given this ecological adaptability, it is unsurprising that baboons are one of the most common commensal species (Kingdon 2003).

Here we developed and applied a survey instrument to investigate human-baboon conflict in an urban environment on the Cape Peninsula, South Africa and test the utility of the *outer model* of the WTM to inform baboon management. In a forthcoming publication we test the inner model. Two hypotheses are tested for the *outer model*: H1: *Exposure* and *Meaningful Events*, both positive and negative, drive perceived C*osts* and *Benefits* by humans; and H2: *Costs* and *Benefits* drive *Tolerance* (Fig 1).

3.2 Methods

3.2.1 Study area

The Cape Peninsula (CP) covers 470 km^2 of the south-western tip of South Africa (latitude: -34.270836, longitude: 18.459778; Fig. B1). The fynbos vegetation, a characteristic of the Cape Floristic Region 'hotspot' (Mittermeier et al. 2004) is the dominant vegetation type. Twelve troops of Chacma baboons (*Papio hamadryus ursinus*) occur on the CP and 11 of these have access to human food. Human-baboon conflict has continued for 300 years since the establishment of the first vegetable gardens at the foothills of Table Mountain (Skead 1980). Past human activities resulted in a marked decline of the population that was historically contiguous throughout the Cape Peninsula. In 1990 the population was legally protected due to their isolation from other baboon populations off the Cape Peninsula. In 1998 mortality rates from conflict with people were unsustainable resulting in highly skewed sex ratios with only 15 adult males remaining (Kansky & Gaynor 2000). Together with local stakeholders, a baboon management strategy was proposed which included re-introduction of dispersing adult males to troops with few males and the Baboon Monitoring Program (BMP). This program employs men from local communities to curtail baboon access to residential areas (Brownlie 2000; Kansky & Gaynor 2000). The BMP has been ongoing since 1999 with various levels of success although it has never been independently evaluated. A brief history of baboon management and conflict between stakeholders since 2000 is described in Koutstaal (2013). Impacts of people on baboons are described in Kansky & Gaynor 2000 and Beamish 2010. Currently the population consists of 484 individuals in 15 troops (Fig. B1; R. Kansky unpublished data 2012). A detailed description of the study site is provided in Appendix B.

3.2.2 Residents survey

We surveyed five of seven communities on the Cape Peninsula with a history of human-baboon conflict, between October 2012 and January 2013 (Fig B1). These communities were of predominantly European decent and represented the cultural majority in the baboon home ranges. Two communities were excluded as they represented a different culture and would have been an insufficient sample size to test the model using Structural Equation Models (Appendix E). All households on streets frequented by baboons were canvassed outside working hours or on weekends. One adult from each household was requested to complete the survey and informed that the objective of the survey was to determine how residents coped with living with baboons. Surveys were completed voluntarily at the residents' convenience and returned via sealed boxes located in their neighborhood. Email and telephone contact information was requested to send reminders after two weeks and then again every two weeks until January 2013.

The survey instrument is presented in Appendix C with descriptions of the four main variables that make up the WTM *outer model*, namely *experience, costs, benefits and tolerance*. In addition to these questions, we asked respondents the question "How much of a problem are baboons for your household? Please tick the appropriate number indicating the extent of the problem where 1 = not a problem at all and 7= a crisis", and "If you have a problem, Please describe the problems you have with baboons"**.** The aim of this question was to understand additional potential costs that may not have been captured in the quantitative questions for the *Cost* variable used in the WTM. The qualitative answers were coded into *tangible* and *intangible costs* in line with the WTM i.e. comments related to monetary losses coded as *tangible costs* and those unrelated to money coded as i*ntangible costs*. *Intangible costs* were further coded into sub-categories using an inductive approach (Babbie and Mouton 2007) and based on common themes that emerged. These sub-categories of listed problems were then translated into unmet needs using the concept of universal human needs (Appendix D).

To determine non-response bias, a random sample of 32 (4.5%) respondents who had agreed to, but actually did not complete the survey, were approached by telephone and email and asked 13 questions (Appendix F-A). Results were analyzed using t-tests and two tailed significance levels.

Ethics requirements comprehensively conformed to the Stellenbosch University Research Ethics Committee: Human Research (Humanora).

3.2.3 Data Analysis

Statistical Package for the Social Science (SPSS.20)(StatSoft Inc. 2012) was used to compute descriptive statistics for variables, with scores used as reported directly by respondents.

We used Partial Least Squares Structural Equation Models (PLS-SEM) (Lowry & Gaskin 2014) to assess the relationships between variables comprising the *outer model* of the WTM. We used the statistical package SmartPLS (Ringle et al 2014). Partial Least Squares (PLS) and the more commonly used Covariance Structural Equation Models (CB-SEM) are the two approaches used in Structural Equation Models (SEM). The PLS method is preferable when the research focus is to develop theories in exploratory research while CB is primarily used to confirm or reject hypotheses of existing concepts and theories (Reinartz et al. 2009; Lowry & Gaskin 2014). Since the WTM is a new theory and this study exploratory in nature PLS was chosen. PLS is widely used in applied social sciences disciplines such as accounting (Lee et al. 2011), marketing and management (Sarstedt et al. 2014). It is less familiar to ecologists but increasingly being used (e.g. Hodapp et al. 2015). Additional reasons for applying PLS over CB in this study were that PLS can cope with complex models with many latent variables, indicators and model relationships as well as smaller sample sizes (Lowry & Gaskin 2014).

SEM models consist of two sub models: a structural model and a measurement model. The measurement model refers to the latent variables and their observed indicators (Appendix C) while the structural model refers to relationships between independent and dependent latent variables (Lowry & Gaskin 2014). The structural model is sometimes referred to as the "inner model" and the measurement model as an "outer model". These should not be confused with the *inner* and *outer model*s of the WTM as these are not related in any way. In order to avoid confusion in the current paper we only use *inner* and *outer model*s in relation to the WTM while measurement and structural models refer to the SEM model.

In PLS-SEM path model diagrams are used to visually display the hypotheses and latent variable relationships. A diagram showing how the WTM can be represented as a PLS-SEM pathway is shown in Fig C1. The questions used in the survey to operationalize the latent variables in the *outer model* of the WTM and which formed part of the PLS-SEM are reported in Appendix C.

We evaluated the Measurement Model (i.e the relationship between a latent variable and its indicators) using four measurements: Indicator reliability (reported as outer loadings), Internal consistency (reported as composite reliability), Convergent validity (reported as average variance extracted (AVE)) and Discriminant validity (Wong 2013; Hair et al. 2014). The Structural Model was assesed using a Colinearity test (Wong 2013; Hair et al.2014). Unlike the CB approach, the PLS method cannot perform Goodness of fit testing (Hair et al. 2014). Although Tenehaus et al. (2004) proposed a PLS goodness of fit index, Henseler and Sarstedt (2012) challenged the usefullness of the index and showed that it could not separate valid models from invalid.

To examine the predictive power of the model, the coefficient of determination (R^2) is typically used (Wong 2013; Hair et al. 2014) and represents the amount of explained variance of constructs in the structural model. The higher the R^2 value the better the construct is explained by the latent variables in the structural model that point at it via structural path model relationships. Higher R^2 values also indicate that the values of the construct can be well predicted via the PLS path model (Wong 2013; Hair et al. 2014). Path coefficients explain how strong the effect of one variable is on another variable in the structural model and correspond to standardized betas in a regression analysis. Values of -1 indicate high negative impact while values of +1 indicate high positive impact (Wong 2013; Hair et al. 2014). Relationships between constructs are shown as single headed arrows and represent directional relationships. With strong theoretical support they are interpreted as causal relationships. The weight of different path coefficients allows their relative statistical importance to be ranked and are reported using bootstrap confidence intervals and significance of path coeficients (Wong 2013; Hair et al. 2014). We did not test an alternative model to the *outer model* of the WTM as removing any of the constructs to test a simpler model did not make theoretical sense. Additional information on PLS-SEM procedure and analysis is provided in Appendix E.

Missing values were replaced using K-Nearest Neighbors, so as to include as many respondents as possible. Less than 5% of surveys required missing value replacement and therefore there was little risk of random data generation. Respondents with over 30% missing values were not considered for replacement and excluded. Model construct scales were standardized using z scores. Because of this the SEM descriptive statistics are not meaningful, and therefore separate descriptive statistics were computed for each construct to provide context for the study. All constructs were considered reflective.

3.3 Results

Of the 707 residents willing to complete the survey (92.1%), 403 (57%) completed and returned it. The most common reasons for refusal were: no time, low interest or for the very old, inability to complete the survey due to cognitive impairment. The respondent profile is reported in Appendix FB. There were no significant differences between respondents who did and did not complete the survey for 12 of the 13 items used (Table F1) however the age of non-respondents was significantly lower than those of respondents.

3.3.1 Partial Least Squares Structural Equation Model

Descriptive statistics for the variables in the PLS-SEM are provided in Appendix G to provide context for the study. Results for evaluation of the measurement model are presented in Table E1 and results for evaluation of structural model are presented in Table E2. Values for these tests were within the recomended limits (Appendix E).

Path coefficient sizes and significance

Bootstrap confidence intervals and significance of path coeeficients are reported in Table E3. Fig. 2 shows the constructs and variables with their related path coefficients sizes and significance. These relationships are further described below with path coefficients reported in parentheses.

Which variables affect tolerance?

Cost Intangible (-0.38) and *Benefit Intangible* (0.4) had equal effects on *Tolerance* while *Cost Tangible* (-0.06) had no significant effect on *Tolerance*. *Exposure* (-0.04), *Positive Meaningful Events* (0.08) and *Negative Meaningful Events* (-0.02) did not significantly affect *Tolerance* (Table E3; Fig. 2).

Which variables affect costs and benefits?

Exposure (-0.38) had the strongest effect on *Cost Tangible* followed by *Negative Meaningful Event* (0.26). *Positive Meaningful Event* (-0.13) had the weakest, but significant effect (Table E3; Fig. 2). *Negative Meaningful Event* (0.35), *Positive Meaningful Event* (-0.31) and *Exposure* (-0.28) all had moderate significant effects on *Cost Intangible*. *Positive Meaningful Event* (0.48) had the strongest effect on *Benefit Intangible* while *Negative Meaningful Event* (-0.26) had a moderate effect and *Exposure* (0.11) had a weak but significant effect.

Which variables affect experience?

Exposure (0.32) had a moderate significant effect on *Negative Meaningful Event* but an insignificant effect on *Positive Meaningful Event* (-0.02) (Table E3, Fig. 2).

Coefficient of determination - R_2

Latent variables *Cost Tangible, Cost Intangible* and *Benefit Intangible* explained 59.8% of the variance in *Tolerance.* Thirty four percent of variation in *Cost Intangible*, 32% of *Benefit Intangible* and 29% of *Cost Tangible* were explained by *Exposure, Positive Meaningful Event* and *Negative Meaningful Event*. Ten percent of variation in *Negative Meaningful Event* was explained by *Exposure* but no variation in *Exposure* explained *Positive Meaningful Event* (Fig 2).

3.3.2 Resident problems and unmet needs due to baboons

Most respondents (78.6%) had some problems with baboons (Fig G1.e). Of these 34.7% had small problems 24.1% had moderate problems and 20% had a serious baboon problem. Overall the mean extent of baboon problem was 3.9 □ 1.98 (scale 1 to 7 where 7 =crisis) (Fig G1.e). Sixty four percent (257) of respondents identified 465 baboon-related problems. Of these, 149 (32%) were *tangible costs* and 316 (68%) *intangible costs* that grouped into nine sub-categories (Table 2; Fig G1.e). There was no relationship between the size of a problem score and the frequency with which a problem was reported (Spearman's rho =-0.382, p=0.25). The most problematic *intangible costs* were: *self, opportunity costs, children, prison* and *baboons* (Table 2; Fig G1.e). The mean size of problem of these was higher than the mean size for *tangible costs* (Table 2). The proposed unmet needs associated with each problem are reported in Table 2.

3.4 Discussion

3.4.1 Support for the Wildlife Tolerance Model

Hypotheses relating to the *outer model* of the WTM were confirmed: perceptions of *costs* and *benefits* explained 60% of *tolerance*, and *exposure* and *meaningful events* approximately 30%. The non-significant path coefficients between *exposure* and *meaningful events* to *tolerance* support the hypothesis that *costs* and *benefits* mediate the relationships between *exposure, meaningful events* and *tolerance*. However since *exposure* and *meaningful events* moderately explained perceptions of *costs* and *benefits* (30%), additional unexplained variance in *costs* and *benefits* remains. Other factors could be the *inner model* variables of the WTM.

3.4.2 Tangible costs do not explain tolerance

HWC mitigation strategies typically assume monetary losses as primary drivers of intolerance (Hulme & Murphee 1999; Distefano 2003; Dickman 2010). This study found that *tangible costs* were not significant in determining *tolerance.* However, *intangible costs* and *intangible benefits* significantly and equally explained tolerance (Fig. 2). This highlights the importance of separating and individually addressing *costs* and *benefits* into tangible and intangible to enable management strategies to identify and target the specific factors driving tolerance on a case-by-case basis. Most strategies focus on reducing *tangible costs* through, for example, compensation schemes, and emphasize the need for *tangible benefits*, such as tourism or trophy hunting. This study highlights that in some circumstances focus on *intangible costs* and *benefits* would be more effective (Jacobs et al. 2011; Barua et al. 2013; Vaske et al. 2013). Future case studies in different contexts will be important to build knowledge of the contexts and species where these may differ.

3.4.3 Universal human needs and intangible costs

Translating the types of problems listed by residents into basic human needs that are not being met (Rosenberg 2003; Tay & Diener 2011) may explain why *intangible costs* were more important than *tangible costs*. Human well-being depends on one's ability to fulfill all basic needs, and when these are not met, negative emotions, dissatisfaction and conflict may result (Max-Neef et al. 1989; Tay & Diener 2011). When the extent of monetary loss impacts a household's livelihood *tangible costs* could be expected to explain *tolerance*. However this was not the case in our study where monetary losses comprised approximately 0.5 to 1% of annual income. Therefore *intangible co*sts presented a greater number of unmet needs compared to *tangible costs*. This finding could be reversed in low-income communities. Future research incorporating a universal human needs approach may prove useful in identifying key elements of costs to communities and the interventions required to mitigate these.

3.4.4 Increasing intangible benefits through positive meaningful events

Meaningful events, both positive and negative, are better predictors of *intangible benefits* than *exposure*. Furthermore, *exposure* does not significantly drive *positive meaningful events*, but *positive meaningful events* most strongly drive *intangible* *benefits*. So, in a management context, how can *positive meaningful events* be enhanced so as to increase the perception of *benefits*? It may be possible to increase *positive meaningful events* in non-residential areas, such as in nature reserves or on the side of the roads. Management of baboons in these areas to enhance a positive baboon experience and prevent negative interactions would be critical. Baboon aggression towards people due to feeding by tourists or easy access to human food in picnic areas and restaurants has been a regular occurrence (Kansky & Gaynor 2000). Current management strategies aim to prevent all human-baboon contact on the Cape Peninsula, which in theory reduces the likelihood of negative experiences. However, this strategy may not be feasible in the urban park context of the study area. Conversely, it also reduces the probability of positive baboon experiences, reducing opportunities to increase tolerance.

3.4.5 Decreasing intangible costs through exposure and negative meaningful events

Contrary to *intangible benefits*, perceptions of *exposure*, *negative meaningful events* and *positive meaningful events* equally drive *intangible costs, i.e.* the more a person is exposed to baboons, the greater their perceptions of *intangible costs.* In addition, the greater the number of *negative meaningful events,* and the lower the number of *positive meaningful events*, the higher the perceptions of *intangible costs (e.g.* negative emotions, feelings of fear, danger, nuisance and/or stress). *Exposure* significantly drives *negative meaningful events* with baboons; therefore reducing *exposure* could reduce the number of *negative meaningful events.* However, since only 10% of *negative meaningful events* are explained by *exposure*, a large amount of variance remains unexplained. Therefore, reducing residents' *exposure* to baboons, as well as the number of *negative meaningful events,* will need to be considered as two separate management interventions. Detailed information and training on how to 1) stop baboons entering homes, and 2) how to behave when they do (e.g. Kansky 2002) can possibly reduce the number of negative meaningful events. Reducing *exposure* should be possible by encouraging residents to make their properties less attractive to baboons (see Kansky 2002) together with reducing the amount of time baboons spend in residential areas through programs that prevent baboons from entering residential areas, such as the Baboon Monitor Program currently operating on the Cape Peninsula (Kansky & Gaynor 2000; www.hwsolutions.org). Regulation and incentives (Heberlein 2012) may also prove effective, for example, by-laws encouraging use of baboon-proof dustbins, compost bins and vegetable gardens, and removal of exotic fruit trees. Ratepayers associations may also encourage property management through innovative competitions. Development of an optimal mix of mechanisms (instruments, incentives and institutions Young et al. 2005) that best enhance resident tolerance whilst better ensuring wildlife persistence is then possible.

3.5 Conclusions

Wildlife management in the 21st Century should increasingly aim to manage interactions between wildlife and people to achieve goals valued by stakeholders (Decker et al. 2012; Booth 2011). This requires conservation interventions to consider the views and attitudes of stakeholders whose co-operation and support is required to achieve conservation goals (Decker et al. 2012). Understanding stakeholders' tolerance towards different species and the perceived effectiveness of management strategies is essential for designing management programs (Decker et al. 2012; Heberlein 2012). Management then becomes a process of mediating a balance between stakeholder tolerance and wildlife persistence. The WTM could be a useful diagnostic tool to identify key factors driving tolerance so as to provide targets for management interventions. Accumulation of this knowledge will allow evaluation of the extent to which these factors are relevant across landscapes and can inform policies and strategies at these scales. These are urgently required given the rapid rate of urbanization, biodiversity loss and global change.

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Appendices A- H : Supplementary Material

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Figure captions

Figure 1. A diagram of the Wildlife Tolerance Model (WTM) proposed in this paper. The two-tiered model consists of an *outer and inner model.* In the *outer model*, *tolerance* is determined by the net perceived *costs* and *benefits* of living with a species based on the extent to which a person *experiences* a species. The *inner model* consists of an additional eleven variables that impact on tolerance through *costs* and *benefits*. The order of *inner model* variables in the triangle is random.*PBC=Perceived Behavioral Control. See Appendix A for additional discussion of variables.

Figure 2. Partial Least Squares Structural Equation Model of latent variables that form part of the Wildlife Tolerance Model. Observed indicators of the latent variables are not shown for ease of representation but are available in Table E1. Circles indicate latent or single item variables as follows: EXPO=exposure, NME= negative meaningful event, PME=positive meaningful event, CT=cost tangible, CI=cost intangible, BI=benefit intangible, TOL=tolerance. Values inside circles are the coefficient of determination (R^2). Lines joining circles are the paths linking latent variables and values adjacent to lines are significant path coefficients. Broken lines are non-significant path coefficients. See Appendix E for additional information on procedures of Partial Least Squares Structural Equation Models.

Table 1. Proposed hypotheses for variables in Wildlife Tolerance Model. See Appendix A for additional discussion of variables.

Variable	Hypotheses
Outer Model Variables	
Exposure	Ho: The more a person is *exposed* to a species the higher the probability of experiencing *costs* and the lower the probability of experiencing *benefits*
Meaningful Events	Ho: The more negative *Meaningful Events* a person experiences the greater the perceived *costs* while the more positive *Meaningful Events* a person experiences the greater the perceived *benefits*.
Tolerance	Ho: *Costs* and *benefits* of living with a species will determine *tolerance* to a species.
Inner model variables	
Interest in Animals	Ho: The more a person is interested in animals in general, wildlife in particular and the more experiential the interest in wildlife the more *benefits* and less *costs* will be perceived to living with wildlife.
Empathy	Ho: People low on trait empathy will perceive more *costs* than *benefits* and therefore show less tolerant behavior towards wildlife. Ho: Women will have higher empathy scores than men and therefore perceive more *benefits* than *costs* to living with wildlife
Anthropomorphism	Ho: Taxonomic groups, species or individual animals that are attributed more mind will be seen as more beneficial than those with less mind attribution and therefore tolerated. Ho: People with low interest in animals will have less non-human representations than those with high interest in animals. Negative animal behavior will be interpreted as being similar to human negative behavior resulting in low *tolerance*.
Taxonomic bias	Ho: Taxonomic groups, species or individual animals that are large, attractive, useful, rare, not dangerous, have positive cultural symbolism look and behave similarly to humans will be perceived as more beneficial than taxonomic groups, species or individual

	animals that are small, unattractive, not useful, common, dangerous, negative cultural symbolism and behave and look differently to humans.
Values	Ho: Individuals and groups prioritizing *self-transcendence* value orientations will perceive more *benefits* to living with damage causing wildlife than individuals prioritizing *self enhancement* values who will perceive more *costs* to living with wildlife.
Wildlife Value Orientations	Ho: Individuals and groups who prioritize mutualistic WVO will perceive more *benefits* to living with wildlife compared to individuals and groups who prioritize utilitarian WVO.
Institutions	Ho: Individuals or communities who have negative perceptions of wildlife governance systems will perceive more *costs* than *benefits* of wildlife.
Personal Norm	Ho: Individuals or groups who have feelings of moral obligation towards a species will perceive more *benefits* than *costs* of living with wildlife and will be more tolerant.
Self-efficacy/behavioral control	Ho: Low self-efficacy in ability to reduce costs of living with wildlife will increase perceptions of *costs* of living with wildlife and reduce *tolerance*
Social Norms	Ho: Individuals who belong to groups or communities where wildlife are perceived to be more costly than beneficial and who have a high need to follow social norms will also perceive more *costs* than *benefits*. Ho: Individuals who belong to groups or communities who implement unsustainable wildlife management interventions and who have a high need to follow social norms will implement unsustainable wildlife management interventions.
Habit	Ho: Individuals or groups who perform habitual activities that are difficult to change in response to living with wildlife will perceive more *costs* of living with wildlife. The greater the habit strength of these activities the greater the perceived *costs*.

Table 2. Types of problems residents have when living with baboons and the possible unmet needs associated with each problem type. Frequency is the number of times a problem category was reported by a respondent. Mean extent of problem is the mean score of the extent of problem scale where 1 was not a problem at all and 7 a crisis. See Appendix D for additional discussion on un - met universal human needs.

Problem type	Definition and examples	Frequency	Mean extent of problem	Un-met needs
Tangible costs				
Damage	Monetary losses to property and food	149	4.27	shelter, food
Intangible Costs				
Self	Worry about personal safety, fear and stress of baboons	17	5.53	safety, ease, consistency
Opportunity costs	Relating to the loss of ability to undertake certain activities such as having a vegetable garden, fruit trees or eating in garden	22	5.14	autonomy, self expression, inspiration, meaning, creativity, stimulation
Children	Worry about welfare of dependents and inconvenience at having to manage them	55	5.09	ease, harmony, nurturing, order, consideration
Prison	A feeling of confinement	60	5.07	autonomy

	indoors due to the necessity to keep the house locked up and windows closed			ease, space, movement
Baboons	Relating to baboon aggressive behavior	19	5.06	Safety, stability
General	A non specific description such as raiding, trying to get into house	16	**4.25**	
Mess	A feeling of resentment or stress at having to clean up after baboons have made a house untidy or pulled rubbish out of bins	57	**4.09**	order, efficacy consideration
Mitigation measures	Frustration or difficulty implementing mitigation measures	36	**4.2**	competence, efficacy, support
Pets/dogs	Worry about welfare of pets, inconvenience at having to manage them and annoyance of noise created from barking	34	**4**	ease, harmony, peace, nurturing, order