

Jaguars and people:
A range-wide analysis of human-wildlife conflict

Thesis submitted for the degree of
Doctor of Philosophy

April 2014

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Abstract

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Hilary Term 2014

Conflict with livestock farmers is the most serious threat to the survival of the jaguar (*Panthera onca*) across its range of 19 countries of the Americas. In this thesis I examine the needs for mitigating human-jaguar conflict at a range-wide scale by: a) reviewing the state of knowledge on the topic, b) modelling the risk of conflict across the range, c) analysing a series of empirical field case studies, and d) proposing appropriate approaches for different levels of conflict. Findings from 43 published studies and 117 expert-described cases show that human-jaguar conflict occurs on large cattle ranches, mixed farms and smallholdings alike. Depletion of prey and poor livestock husbandry are reported as the key reasons for depredation, regardless of ecological, cultural or socio-economic context. Attitudes and tolerance towards jaguars are not necessarily linked to losses, so recent research has focussed on understanding the behaviours of farmers. With 65% of the remaining jaguar range outside of protected areas, effective strategies for coexistence with farmers are essential. By combining geospatial datasets with expert-based information, spatial patterns of human-jaguar conflicts were presented in a predictive model of conflict hotspots. Around 85% of the total jaguar range, 72% of the total Jaguar Conservation Units area and 90% of the Jaguar Corridor area overlap with livestock, and 15% of the jaguar range has risk of conflict. Regions in which jaguars are repeatedly persecuted may become ecological traps and decimate populations. An aggregate study of 17 case studies across seven countries exposed a very large variety of geographic, agronomic and socio-economic contexts. Both within and across case studies there are considerable differences in farmers' experiences with livestock losses, concerns about depredation, levels of tolerance and attitudes, as well as social norms towards jaguars in each community. No situational factors could be used to predict how farmers perceive jaguars and deal with depredation. The only pattern consistent across case studies was that attitudes towards jaguars are most likely predicted by a factor of perceived losses combined with the social norms of the community. In most scenarios, correctly balanced strategies of improving husbandry combined with behaviour-influencing methods may be the best way forward. To this end, a conceptual model is proposed, which distinguishes three levels of conflict and explains the importance of addressing any underlying history of grievances or incompatibility of values as part of any human-wildlife conflict mitigation strategy.

Acknowledgements

This DPhil thesis was supervised by Professor David Macdonald, without whose guidance and support it would not have been feasible. The endeavour was funded wholly by the North of England Zoological Society (Chester Zoo). I thank my Chester Zoo colleagues for their support during the course of this work, in particular Roger Wilkinson for his unconditional support, but also Mark Pilgrim, Gordon McGregor-Reid, Jayne Quinn, Stephanie Sanderson and Scott Wilson.

I am also grateful for the technical assistance and expertise provided by: Scott Wilson, Chloe Inskip, Samantha Earle, Alan de Barros, and Carmen Quiroga Pacheco, Silvio Marchini and Erika Cuellar, Paul Johnson, and for reviewing drafts of questionnaires and manuscripts: David Macdonald, Claudio Sillero-Zubiri, Paul Johnson, Brian McQuinn, Alan de Barros, Ronit Amit, Silvio Marchini, and Amy Dickman. Additional academic support was provided by Richard Ladle, Tim Guilford, and Dawn Burnham.

I thank my collaborators who helped make the field data collections possible by providing local knowledge, contacts, and logistics: Claudio Sillero-Zubiri, Rogerio de Paula, Tadeu de Oliveira, Ronaldo Morato, Jose Soto, Alan Hesse, Erika Cuellar, Rosario Arispe, Silvio Marchini, Mario di Bitetti, Esteban Payan, John Polisar, Carlos Lopes-Gonzales, Linde Ostro, Alan de Barros, Howard Quigley, Ronit Amit, Daniel Corrales, Franklin Castaneda, Pablo Perovic, and Roberto Salom.

For their logistical advice and assistance in interviewing over 400 farmers in seven countries I am grateful to Alan de Barros, Karla Camargo, Claudia Moreno Arzate, Lorena Lobos, Mario Ramos Solis, Pablo Cuellar, Tiago Henicka, and Alejandro Matthey Trigueros. I also thank the 86 jaguar experts in Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Venezuela and USA who took the time to respond to the first survey, and around 420 farmers in seven of these who countries agreed to be interviewed for the second survey.

For their moral support in particular, I am grateful to Michelle Lee, Ruth Brandt, Magdalena Bennett, Erika Cuellar, Sandra Baker, Andrea Fidgett, Christos Astaras, Emre Can and Brian McQuinn. For expertly looking after my children while I worked on this thesis, I am very grateful to Wendy Pinker, Tilly Miller-Mundy and Anja Laurenz. Finally, for their neverending patience and encouragement I thank my parents Otfried Zimmermann, Inge Bösken-Kanold and Jo-Anne Birnie-Danzker; as well as Christian Rohlf, and for their eternal cheer and enthusiasm, my dearest sons Tom and Max Rohlf.

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Glossary

Human-wildlife conflict: the situation that arises when wildlife poses a direct and recurring threat to the livelihoods or safety of people, who respond by repeatedly persecuting the species they blame for their losses (adapted from Inskip & Zimmermann, 2009)

Jaguar Conservation Unit: “Areas with a stable prey community, currently known or believed to contain a population of resident jaguars large enough (at least 50) breeding individuals to be potentially self-sustaining over the next 100 years, or areas containing fewer jaguars but with adequate habitat and a stable, diverse, prey base, such that jaguar populations in the areas could increase if threats were alleviated” (Sanderson et al., 2002)

Jaguar Corridor: a modeled pathway of interconnected protected areas through the entire jaguar range from the USA to Argentina. Defined by a least-cost pathway analysis by Rabinowitz & Zeller (2010), its purpose is to allow for genetic exchange across jaguar sub-populations and increase the habitat available to them.

Social Marketing: an approach developed for fostering or changing people's behaviour for the social good (rather than for financial gains) – i.e. to benefit of individuals and society as a whole (*cf* McKenzie-Mohr, 2011).

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Introduction

Human-wildlife conflict

Conflicts between farmers and wildlife are common worldwide and present a serious threat to the survival of many endangered species, in particular charismatic top predators and large herbivores (Kellert et al., 1996; Mech & Boitani, 2003; Thirgood et al., 2005; Woodroffe et al., 2005d; Inskip & Zimmermann, 2009). I define human-wildlife conflict as a situation where wildlife poses a direct and recurring threat to the livelihoods or safety of people, who respond by repeatedly persecuting the species they blame for their losses (Inskip & Zimmermann, 2009).

Human-wildlife conflict affects most large carnivores, elephants, many primates, sharks, seals, and birds of prey (Mech & Boitani, 2003; Treves & Karanth, 2003; Thirgood et al., 2005; Woodroffe et al., 2005d). It has contributed to the extinction of several species including the sheep-predating Thylacine (*Thylacinus cynocephalus*) and Falkland Island wolf (*Dusicyon australis*), and the fruit crop-raiding Carolina parakeet (*Conuropsis carolinensis*) (Woodroffe et al., 2005c; IUCN-SSC, 2008; McKnight, 2008). Other species too have suffered much population and range loss as a result of retaliation, for example prairie dogs, wolves, wild dogs, bears, lynx, and most large cats, and a number of birds (Woodroffe et al., 2005c). Carnivores are particularly affected because of their ecological spatial requirements (Linnell et al., 2001; Macdonald & Sillero-Zubiri, 2002) and human-carnivore conflicts appear to be increasingly frequent in many parts of the world (Treves & Karanth, 2003).

Many felids are acutely at risk from the effects of human-wildlife conflict. In a global review of human-felid conflict, C. Inskip and I reviewed 349 sources of literature on the topic (Appendix 3). We found that conflict affects 29 of the 37 felid species world-wide, and for nine of these it is a serious threat to their survival. These nine species included the seven largest cats: tiger (*Panthera tigris*), lion (*Panthera leo*), jaguar (*Panthera onca*), leopard (*Panthera pardus*), snow leopard (*Uncia uncia*), puma (*Puma concolor*), and cheetah (*Acinonyx jubatus*), which all have average body weights of >50kg, plus the caracal (*Caracal caracal*, 17kg) and the Eurasian lynx (*Lynx lynx*, 23kg). For the jaguar especially, conflict with farmers has become the most serious threat to the survival of the species (Medellin et al., 2002; Zeller, 2007).

Although studies on human-felid conflict focus on different questions and measure its impacts in different ways (Inskip & Zimmermann, 2009), many studies conclude that depredation rates tend to be highest in places where there is a permanent or seasonal depletion of natural prey (e.g. Saberwal et al., 1990; Pedersen et al., 1999; Reza et al., 2002; Polisar et al., 2003; Athreya et al., 2004; Packer et al., 2005; Johnson et al., 2006; Melville & Bothma, 2006). Authors of human-felid conflict studies also widely agree that poor livestock herding or husbandry practices are to blame for most cases of depredation (Mishra et al., 2003; Thirgood et al., 2005).

Many of the affected species are found largely outside of protected areas, which is a particular concern, for example, for tigers in the Russian far east, cheetahs in Namibia, and jaguars in central Brazil (Marker et al., 2003a; Miquelle et al., 2005; Silveira et al., 2008). However, even protected areas do not truly provide security for carnivores (Johnson et al., 2005; Wang & Macdonald, 2006) as their boundaries often become hotspots of conflict. Where habitats meet human-dominated landscapes, protected area edges can create

population sinks, where the persecuted wildlife is killed at a rate too frequent for the local population to sustain (Woodroffe & Ginsberg, 1998; Harcourt et al., 2001). For large carnivores, edge effects can be more significant in determining species survival than the total area of habitat (Purvis et al., 2000; Woodroffe, 2001).

Retaliatory killing can have detrimental effects, particularly on the large cats, and has led regionally to the mortality of 47% of cheetah (Marker et al., 2003a) 46% of Eurasian lynx (Andren et al., 2006) and up to 50% of tigers (Miquelle et al., 2005). Where actual mortality is difficult to measure, surveys with ranchers have given us indications of the extent of likely persecution in retaliation for livestock depredation: for example, 39% of respondents had hunted cats in Belize (Brechin, 2003), 14% of herders in four regions of Mongolia had killed snow leopard (Allen et al., 2002), and 88% of ranchers interviewed in the Brazilian Pantanal said that other ranchers kill jaguars in retaliation for cattle losses (Zimmermann et al., 2005).

Living near carnivores, or elephants, or other potentially dangerous, species inevitably affects people's lives - sometimes severely. While for relatively wealthy landowners the loss of a few head of livestock may be economically little more than a nuisance, in poorer scenarios, or where people's safety is genuinely at risk, human-wildlife conflicts can be detrimental (Bagchi & Mishra, 2006; Zimmermann et al., 2009). In Bhutan, for example, depredation by tigers causes a considerable loss of income to farmers around Jigme Singye Wangchuk National Park (Wang & Macdonald, 2006), while in Kenya, African wild dogs were responsible for average income losses of 22% (Woodroffe et al., 2005a) and crop damage by elephants can be catastrophic, leading not only to devastating income losses but also the deaths of hundreds of people each year (Naughton-Treves et al., 1999)

However, the extent to which people tolerate wildlife is often not directly linked to the economic damage these species may cause, and retaliation is not necessarily proportional (Frank & Woodroffe, 2002; Conforti & de Azevedo, 2003; Marker et al., 2003b; Silva-Rodriguez et al., 2007). Instead, tolerance is influenced by a variety of socio-cultural factors which may include attitudes towards the species (Athreya et al., 2004; Rabinowitz, 2005; Zimmermann et al., 2005; Ramonach et al., 2007), perceptions of the damage (Macdonald & Sillero-Zubiri, 2002; Marker et al., 2003a; Madden, 2004), beliefs, values, religion, and social norms (i.e. commonly-held beliefs about how people behave in a given context) (Hussain, 2000; Shivik et al., 2003; Naughton-Treves & Treves, 2005; Ale et al., 2007) and the economic dependence on livestock (Bagchi & Mishra, 2006).

Furthermore, perceptions of conflict are often formed by a few memorable or catastrophic events and may even reflect opinions and stories from others in the community (Naughton-Treves & Treves, 2005; Treves et al., 2006; Macdonald, 2013). Like other conservation challenges, human-wildlife conflict is about the actions of people, so an understanding of what shapes behaviours and how to influence them, must be central to any efforts to resolve them (Verissimo, 2013).

Jaguars, livestock and people

The jaguar is the third-largest of the wild cats, and the largest terrestrial predator of the Americas. A very adaptable and generalist carnivore, it survives in all of the continent's habitats that are generally below 1000m altitude (Nowell & Jackson, 1996), including tropical lowland and montane forests, semi-arid xerics, swamps, grasslands, temperate and dry forests, and mangroves (Sanderson et al., 2002).

Historically the jaguar ranged from Arizona, New Mexico and Texas in the United States to the Río Santa Cruz in Argentina. Today, its range has been reduced by approximately 40%, yet it is still widespread, surviving in 19 range states and is found in northern Arizona, Mexico, and in all central and south American countries and French Guiana, except Chile, where it never occurred, and Uruguay and El Salvador, where it has already become extinct (Sanderson et al., 2002).

Few pristine areas remain in which jaguars survive undisturbed by human influences. Sixty-five per cent of the remaining jaguar range is outside of protected areas (Sanderson et al., 2002; Zeller, 2007), and it is here that they come into contact with livestock, which commonly results in retaliatory killing by farmers. Direct persecution of jaguars, as well as the hunting of their wild prey, is the most serious and widespread threat to their survival (Zeller, 2007; Rabinowitz & Zeller, 2010). Listed as *Near Threatened* by IUCN and on CITES Appendix I, (Caso et al., 2008; IUCN, 2013) it is strictly protected over most of its range (Nowell & Jackson, 1996).

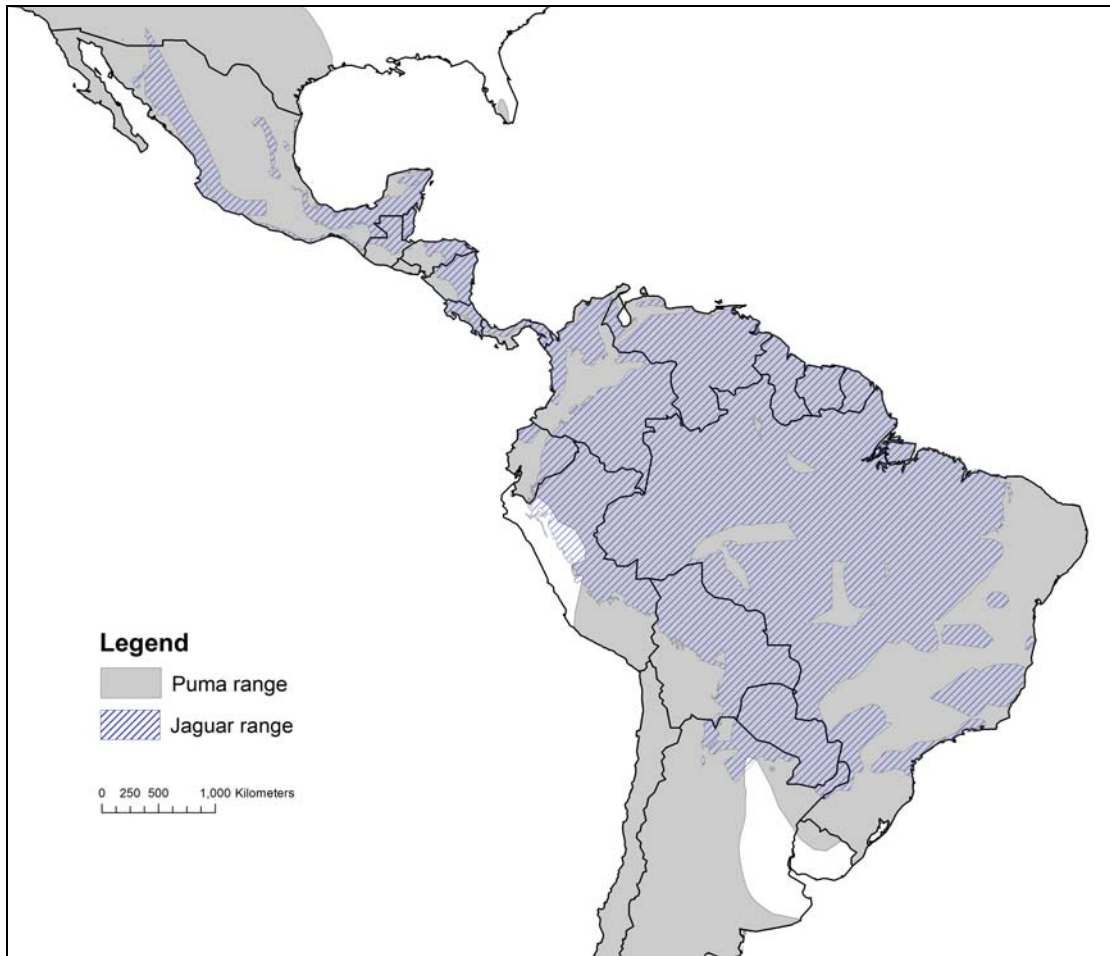
Jaguars have been observed to prey on any of around 85 species, including capybara, caiman, turtles, deer, armadillo, monkeys, anteater, anaconda, fish, and birds (Mondolfi & Hoogsteijn, 1986; Nowell & Jackson, 1996). Where possible, jaguars will also prey on livestock, in particular cattle, but also horses, donkeys, pigs, sheep and goats, and for some individuals this may constitute their main prey (Hoogsteijn et al., 1993; Cavalcanti & Gese, 2010). Jaguars are also able to kill bulls, but most often attack calves and young animals (Hoogsteijn & Mondolfi, 1992).

The problem has existed since livestock were introduced to Latin America (Rabinowitz, 2005) and at times very seriously affected the livelihoods of ranchers, for example, Im

Thurn (1883) recorded that hardly a night passed in Guyana when cattle were not attacked by jaguar. Large numbers of jaguars were shot each year in retaliation for depredation, a practice which recent studies have shown to be continuing in many places (e.g. Moreno & Olmos, 2008; Carvalho & Pezzuti, 2010; Rosas-Rosas & Valdez, 2010; Garrote, 2012). In cattle ranching communities, killing jaguars acquired cultural significance, and many were hunted for sport (Roosevelt, 1926; Almeida, 1990).

Livestock husbandry practices often do little to help the situation (Rabinowitz, 2005). Many large cattle ranches operate extensive farming practices, allowing their hundreds or thousands of cattle to roam freely and become easy prey for jaguars. In addition to this, veterinary care, breeding strategies and guarding or protection are often so poor that depredation is only a minor cause of mortality (Schaller, 1983; Quigley & Crawshaw, 1992; Hoogesteijn et al., 1993).

Jaguars are sympatric with pumas throughout most of their range (Map 1), and pumas also kill livestock, but the two species are regarded differently by farmers, and jaguars tend to be assigned the larger share of the blame (Conforti & de Azevedo, 2003; Palmeira et al., 2008; Soto-Shoender & Giuliano, 2011). Farmer's views about jaguars vary however, for example, cattle ranchers in the Pantanal see them as a menace (Cavalcanti & Gese, 2010; Marchini & Macdonald, 2012), while migrant farmers at the edge of the Amazon and smallholders in Petén, Guatemala fear them (Marchini & Macdonald, 2012; Soto-Shoender & Main, 2013) and in some farming communities such as among Chinantec and Mayan people in Mexico, people associate positive spiritual values with jaguars (Figel et al., 2011; Navarro-Serment et al., 2011).



Map 1: Distributions of the puma (*Puma concolor*) and jaguar (*Panthera onca*) across the Americas.

Research aims and questions

The jaguar faces the same threat across all parts of its geographic range but in very different local contexts. Each case of conflict is likely to be unique in many respects, requiring individually-designed mitigation efforts appropriate for the local ecological and socio-economic conditions. However, some scenarios also appear to have striking similarities, for example among large cattle ranching communities in seasonally flooded savannahs of the Pantanal, Beni or Llanos.

Conservation strategies for wide-ranging species require efforts at multiple scales, and can benefit greatly not only from best practice at local levels, but also from a thorough understanding of the variety of scenarios that exist across a species' range. In this thesis I cross-examine the state of the knowledge about human-jaguar conflict from expert opinion, empirical data, spatial information and conceptual models with the aim of offering new insights to assist strategic planning for jaguar conservation across the Americas.

The purpose of this research is to determine and distil what is needed to mitigate the threat of conflict to the survival of the jaguar across its range. To this end, four questions arise which form the framework of this thesis, and each in turn the focus of the four chapters that follow:

1) What is the state of knowledge about human-jaguar conflict?

- a) In what geographical and socio-economic contexts do conflicts occur?
- b) What aspects have been studied, where, and at what scales?
- c) What patterns or predictors of depredation have been observed?
- d) What do we know about attitudes, and tolerance or killing of jaguars?
- e) What solutions and mediation approaches have been recommended?

2) Where does human-jaguar conflict occur?

- a) How much of the jaguar range overlaps with livestock, people and protected areas?
- b) Are there any apparent hotspots of risk for conflict?
- c) How do Jaguar Conservation Units and the Jaguar Corridor fare against such hotspots?
- d) Which regions and countries have the most risk of conflict?
- e) Where might conflict emerge in future?

3) How do cases of human-jaguar conflict differ from each other?

- a) What variety of human-jaguar conflict scenarios exist across the range?
- b) How unique are cases of human-jaguar conflict?
- c) Are there any patterns that are generalizable across cases of conflict?
- d) Are there any insights about tolerance or attitudes that can aid mitigation efforts?
- e) Is it possible to scale-up context-dependent insights?

4) Why are some conflicts more easily resolved than others?

- a) Why does reducing depredation not necessarily resolve a given conflict?
- b) How can we conceptualise human behaviour to resolve conflict more effectively?
- c) How can we rapidly identify the level of conflict in a given situation?
- d) Which scenarios tend to involve the most complex conflicts?
- e) What are the appropriate approaches for the different levels of conflict?

The four chapters of this thesis build on each other. First, I explore and review the state of current knowledge about human-jaguar conflict, looking at the entire species range and using expert opinion combined with literature review. This information then contributes to the next step of a spatial general overview which illustrates the risk areas for conflict at the range-level. The study then “zooms in” to a selection of local-level case studies in seven of these countries, in which I examine patterns of conflict in more detail. To conclude the study I ask what it takes to address human-jaguar conflict effectively in real individual situations. In this way, this thesis provides the most comprehensive overview of human-jaguar conflict carried out to date, spanning across all range states and across all scales, from the individual level to communities, and from regions to international levels of enquiry (Fig. 1).

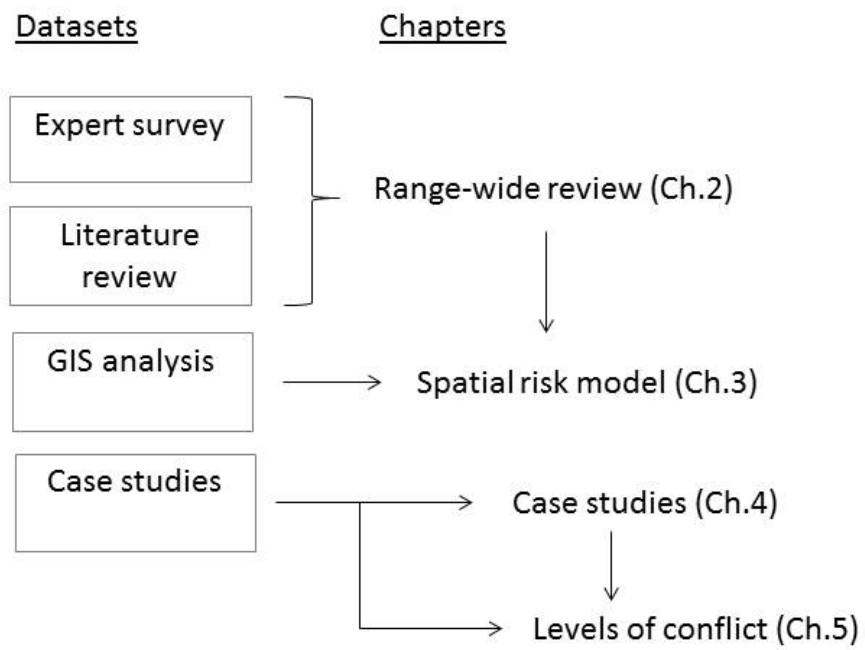


Fig.1. Schematic diagram of the thesis components

Thesis structure

CHAPTER 2:

The state of knowledge about human-jaguar conflicts across Latin America: a synthesis of expert opinion and empirical research

The aim of this study was to compile the most relevant knowledge about human-jaguar conflict available to date and present this in a useful format for jaguar conservation strategies and range-wide planning. I carried out a range-wide questionnaire survey of jaguar experts and supplemented this with a systematic review of published studies, to assemble a most comprehensive synthesis of the current state of knowledge on the subject of human-jaguar conflict. This paper is intended to provide a thorough and objective synopsis of the topic relevant for initiatives at local, landscape and range-wide scales.

CHAPTER 3:

A range-wide spatial model of human-jaguar conflict hotspots

By combining geospatial datasets of the jaguar range, protected areas, livestock densities and human geography with expert-based information about jaguar conflicts, I characterised the main spatial patterns of human-jaguar conflicts and present a predictive model of conflict risk at a range-wide scale. I calculated the extent of risk in strategically key areas such as Jaguar Conservation Units and the Jaguar Corridor, and generated a range-scale map to illustrate and discuss the key hotspots. By exploring spatial patterns of human-jaguar conflict in relation to patterns of human influences, I draw attention to the main areas of current or emerging conflict risk for consideration in future jaguar conservation efforts.

CHAPTER 4:

Understanding human-jaguar conflict: lessons from case studies across the species' range

I conducted seventeen case studies in seven countries in order to search for any patterns at local scales which could inform strategies at the range-wide scale. Through these case studies I show a considerable variety of geographic, agronomic and socio-economic contexts, within heterogeneous compositions of farm types, extent of losses to jaguars, economic dependency on livestock and education levels. Using analyses that test for correlations, clusterings and predictive associations, I attempt to find factors could be used to predict how farmers perceive jaguars and handle depredation, and discuss to what extent these may guide future directions in human-jaguar conflict management.

CHAPTER 5

Deconstructing human wildlife conflict

Finally, I propose a conceptual model to help us understand some of the complexities of the human dimensions of conflict. This model categorises conflicts into three levels of intensity, which we call *dispute*, *underlying*, and *deep-rooted*. I illustrate this model using the data from the case studies in Chapter 4 and explain how appropriate responses to these levels will make mitigation efforts more likely to succeed. To uncover whether there are issues beneath the visible issue of jaguar depredation, there are certain indicators that can be observed, which I outline and discuss in this last paper.

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The state of knowledge about human-jaguar conflicts across Latin America: a synthesis of expert opinion and empirical research

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Abstract

Conflict with livestock farmers is the most serious threat to the survival of the jaguar (*Panthera onca*), across the Americas. We carried out a range-wide expert survey of human-jaguar conflict and a systematic review of published studies to reveal the state of knowledge on this issue. Human-jaguar conflict occurs in all range states, on large cattle ranches as well as on small farms. Depletion of wild prey and poor livestock husbandry are reported by the experts as the main reasons for depredation, regardless of ecological, cultural or socio-economic context. Although losses of livestock are not always detrimental to livelihoods, low tolerance of jaguars prevails throughout the range, and leads to retaliatory killing of the cats. While patterns of predation on livestock have been studied extensively for the past two decades, more recent research has focussed on understanding the drivers of the behaviours of farmers. The overall consistency of findings suggests that future investments may most fruitfully be directed towards applied efforts and focus on three interlinked objectives: protecting wild prey, improving livestock husbandry, and influencing farmers' behaviours.

Introduction

Jaguars (*Panthera onca*) range from northern Mexico to northern Argentina, across 18 countries of Central and South America (Sanderson et al., 2002), with a few individuals also found near the US-Mexico border in southern Arizona (Rabinowitz, 1997; McCain & Childs, 2008). Few pristine areas remain in which the jaguars can survive, protected from human influences and threats. Sixty-five per cent of the remaining 11 million km² jaguar range is outside protected areas (Chapter 3, Zeller, 2007), and it is here that jaguars come into contact with livestock, on which they occasionally prey, and which leads to retaliatory killing by farmers.

This human-jaguar conflict is the most widespread threat for the survival of the jaguars species, which is listed as *Near Threatened* by IUCN (Caso et al., 2008; IUCN, 2013). Hunting of jaguar prey and direct persecution of jaguars (in connection with livestock depredation) are, according to 130 jaguar experts, the most serious threats to the survival of the jaguar (Zeller, 2007). Human-jaguar conflicts have been documented in all range states. Around 85% of the jaguar's geographical range has some overlap with livestock and therefore potential for conflict with people (Chapter 3).

With conflicts as the main, and increasing, threat to the survival of jaguars, and a paucity of resources to manage each situation individually, conservation efforts would be helped by understanding the patterns, predictors and hotspots of conflict, so that limited funds and expertise might be prioritized accordingly. The aim of our study was to compile the most relevant knowledge gathered by experts to date and present this in a synthesis useful for jaguar conservation strategies and range-wide planning.

Most studies of human-jaguar conflict focus on single locations and report the characteristics of conflict as case studies, e.g.: Rabinowitz, 1986; Hoogesteijn et al., 2002; Saenz & Carrillo, 2002; Conforti & de Azevedo, 2003; Polisar et al., 2003; Vidolin et al., 2004; Navarro-Serment et al., 2005; Zimmermann et al., 2005; Altrichter et al., 2006; Michalski et al., 2006; Azevedo & Murray, 2007a; Azevedo & Murray, 2007b; Palmeira & Barrella, 2007; Palmeira et al., 2008; Rosas-Rosas et al., 2008; Palmeira, 2009; Carvalho & Pezzuti, 2010; Cavalcanti & Gese, 2010; Gordillo Chavez, 2010; Rosas-Rosas et al., 2010; Rosas-Rosas & Valdez, 2010; Cruz et al., 2011; Figel et al., 2011; Navarro-Serment et al., 2011; Soto-Shoender & Giuliano, 2011; Torres & Ramos-Fernández, 2011; Cavalcanti et al., 2012a; Cavalcanti et al., 2012b; Soto-Shoender & Main, 2013 .

A few studies, such as Hoogesteijn et al., 1993; Saenz & Carrillo, 2002; Cavalcanti et al., 2010; Marchini & Macdonald, 2012; Amador-Alcala et al., 2013; Carvalho, 2013 , have also systematically compared two or more case studies, to identify and explain differences among them. Several others have discussed general patterns of human-jaguar conflict based on insights at national scales, e.g. (Hoogesteijn et al., 2002; Crawshaw, 2003; Silveira et al., 2008; Jedrzejewski et al., 2011; Zarco-Gonzalez et al., 2012).

There is much expertise in the field of jaguar biology and conservation, and in addition to the authors cited above, there are many more authorities who can provide very valuable experience from their project sites. Expert-based surveys are a useful method for assembling such knowledge – particularly at a range-wide scale, where the collection of new, empirical data would be prohibitively expensive. Such expert-based data are helpful for landscape species conservation strategies, and in matters where pragmatic viewpoints for problem-solving are of particular interest (Cowling et al., 2003; Eycott et al., 2011).

Expert-based datasets can be limited by two possible sources of uncertainty. In the context of our study, random error could occur if experts provide different information or opinions about a given same sample of human-jaguar conflict. Systematic error may arise out of the difference in values and opinions held by the survey respondents (i.e. the jaguar experts) compared with, for example, those of cattle ranchers (Whitefield et al., 2007).

However, rather than relying solely on expert opinion, we also carried out a systematic review of the topic of human-jaguar conflict, in which we gathered quantitative, qualitative and spatial information from relevant published studies. Combining expert opinion with either literature or empirical data is not an uncommon approach, and Clevenger *et al* (2002) showed that literature reviews of empirical studies perform almost as well as newly assembled empirical data.

Here we bring together the findings from the empirical literature together with our independent survey of experts from nearly all jaguar range states, to present the most comprehensive current state of knowledge to date on the subject of human-jaguar conflict.

This paper is intended to provide a thorough and objective synthesis of the topic. Through our expert survey and systematic review we attempt to answer: in what geographical and socio-economic contexts do conflicts occur, what aspects have been studied, what patterns or predictors have been observed, what we know about attitudes, tolerance and killing of jaguars, and what solutions have been recommended.

Methods

Expert Survey

We designed a short (20-question) self-administered questionnaire to reveal the characteristics of human-jaguar conflict cases (see Appendix 1). The respondents were contacted by email and the survey could be filled in using the online software *Survey Monkey* (www.surveymonkey.com) or via a Word document attachment. The variables explored in this questionnaire focussed on the geographic and socio-economic context of each described conflict case (such as land use type, land tenure, and cultural identities), the extent of depredations and retaliations, the expert's impression of the severity of the situation, levels of tolerance and third-party assistance received, and the condition of the local habitat and prey availability.

The survey was pilot-tested in person with experts working on jaguar conservation in Guatemala, Belize, Bolivia and Brazil; then revised and translated into Spanish and Portuguese versions by native speakers with subject knowledge. The national languages of the jaguar range states are: Spanish (13 countries), English (3), Portuguese (1), French (1) and Dutch (1). The survey was not translated into French or Dutch because our contacts for those regions spoke English.

Survey sampling and data collection

A list of around 250 jaguar experts (potential survey respondents) was compiled from the authors' contacts, the jaguar literature, websites of jaguar projects and suggestions from other experts. The number of potential respondents varied greatly for each country as, for

example, there are many people working on jaguar conservation in Mexico and Brazil, but very few in the Guianas.

The survey was sent to the entire sampling frame, using purposive (or selective) sampling method, combined with snowball sampling (De Vaus, 2007; Lund & Lund, 2010). In other words, we sent surveys to all known jaguar experts and asked them to suggest further experts. Although this is a non-random sampling method, it was appropriate for our objective of gathering as much expert opinion and information as possible from a relatively small population of eligible respondents. While this does limit the extent to which we can make statistical generalisations from our findings, it allows for exploratory analyses about general patterns of conflict across the species' range – which was our primary aim.

The respondents were contacted individually and in their native language. The survey was sent between April and September 2008 to 170 jaguar contacts by email, providing the weblinks and document options in all three languages.

Literature Review

Relevant literature was collected by gathering all the papers on human-jaguar conflict listed in the bibliography of the website *www.jaguarnetwork.org* created by Zimmermann & Inskip (2008). Then, following the method we used in Inskip & Zimmermann (2009), this was augmented with web searches through *Web of Knowledge* (v.5.10, 2013, www.webofknowledge.com), the *IUCN/SSC Cat Specialist Group Digital Library* (<http://lynx.uio.no/lynx/catsglib>), and *Google Scholar* (<http://scholar.google.com>), as well as citation searches of the references cited in each paper reviewed, to identify further relevant literature, until no further new sources were found.

Only published papers and book chapters were included in the review. We did not include unpublished 'grey' material such as project reports, nor magazine articles and theses. This way we avoided duplications, as a number of the theses have been written into published papers, and controlled for quality, as it is reasonable to expect academic published papers to be of a good standard (Adams & Sandbrook, 2013).

Only empirical studies in which new data had been collected - not opinion pieces or commentaries - were included. We searched for keywords, with the aim of finding all relevant information but limiting the returns to those most likely to be relevant (Pullin & Stewart, 2006). The key words were *jaguar* in combination with at least one of the words: *attack, predation, depredation, killing, conflict, coexistence, cattle, livestock, mitigation, mortality, attitude, perceptions, and persecution*. The search was repeated with Spanish and Portuguese translations of the keywords. Occasionally this led us to papers that were not about human-jaguar conflict, e.g. the combination of "jaguar" and "predation" brought forward a number of papers about jaguar ecology or comparisons of jaguar and puma predation patterns. These were then excluded from the list of papers to be reviewed. Publications that had no keywords – such as book chapters – were skim-read to determine whether they contained data or discussion about human-jaguar conflict, and included or discarded accordingly.

Data analysis

The data from the expert surveys submitted online were collected using *Survey Monkey* software, which could be downloaded into *Excel*, and those received via word documents were added to the database manually. Any duplicates, where people had described the same case of conflict in the same location, were removed from the dataset by flip of a coin. The survey data were analysed using *SPSS (v. 20, 2012)*. Correlations between variables in the expert survey were tested with Spearman's rho. Adjustments for multiple testing to

control type 1 error rate were not been applied, as it is not possible to decrease type 1 error rates without increasing the rate of type 2 error (Perneger 1998). Interpretation of results focuses on patterns rather than individual tests.

The literature was analysed by entering quantitative information into a spreadsheet, as well as geo-referencing each study on our GIS database (see Chapter 3) to identify positions relative to geographic variables at each point. GIS mapping was done in ArcView v10.1 (ESRI Inc., Redlands, CA). The qualitative information of each paper was collected by transcribing the key findings and arranging the information into subtopics and tables for discussion.

Results

Here we describe the results from the expert survey and the empirical literature under the sub-topics discussed. To assist the reader, the words “*Expert Survey*” and “*Literature Review*” precede each section to clarify the source of the information.

Characteristics and geography of the expert survey and the literature

Expert Survey: The survey was sent to 170 people, of which 86 responded (response rate 51%) and collectively filled out 120 survey forms, which, after removal of duplicates, left 117 samples (described conflict cases) for analysis. A comparison of the six samples in which three cases had been described by two different authors each, showed that their responses were the same for 73% of the questions. The majority (71%) of respondents used the web-based survey, and 72% of respondents chose to respond in Spanish or Portuguese. Responses were received from 17 range states – i.e. all jaguar range countries except Suriname and Guyana, where we were unable to find contacts able or willing to fill out the questionnaire. The distribution of responses is shown in **Table 1**.

Range State	Number of contacts	Number of people replied	Number of surveys filled out	Proportion of total responses	Response rate	Jaguar range area (km ²)	% of country area containing jaguar range	% of global jaguar range
Argentina	13	8	16	13.3%	62%	189,176	6.8%	1.7%
Belize	7	4	4	3.3%	57%	21,640	97.9%	0.2%
Bolivia	16	10	14	11.7%	63%	754,301	69.4%	6.7%
Brazil	57	24	36	30.0%	42%	6,015,075	71.0%	53.8%
Colombia	9	3	6	5.0%	33%	822,549	72.5%	7.4%
Costa Rica	7	6	7	5.8%	86%	46,107	90.3%	0.4%
Ecuador	4	4	4	3.3%	100%	118,408	46.4%	1.1%
French Guiana	2	1	1	0.8%	50%	83,453	99.8%	0.7%
Guatemala	11	7	8	6.7%	64%	67,944	62.3%	0.6%
Guyana	2	0	0	0.0%	0%	210,373	99.9%	1.9%
Honduras	2	1	1	0.8%	50%	54,270	48.4%	0.5%
Mexico	13	6	10	8.3%	46%	572,435	29.3%	5.1%
Nicaragua	3	1	1	0.8%	33%	91,248	71.2%	0.8%
Panama	3	1	1	0.8%	33%	49,783	67.2%	0.4%
Paraguay	9	5	5	4.2%	56%	398,704	100.0%	3.6%
Peru	3	2	3	2.5%	67%	728,598	56.4%	6.5%
Suriname	2	0	0	0.0%	0%	144,858	99.9%	1.3%
USA	2	1	1	0.8%	50%	6,222	0.1%	0.1%
Venezuela	5	2	2	1.7%	40%	814,411	89.4%	7.3%
Sums	170	86	120	100.0%	51%	11,189,555	-	100.0%

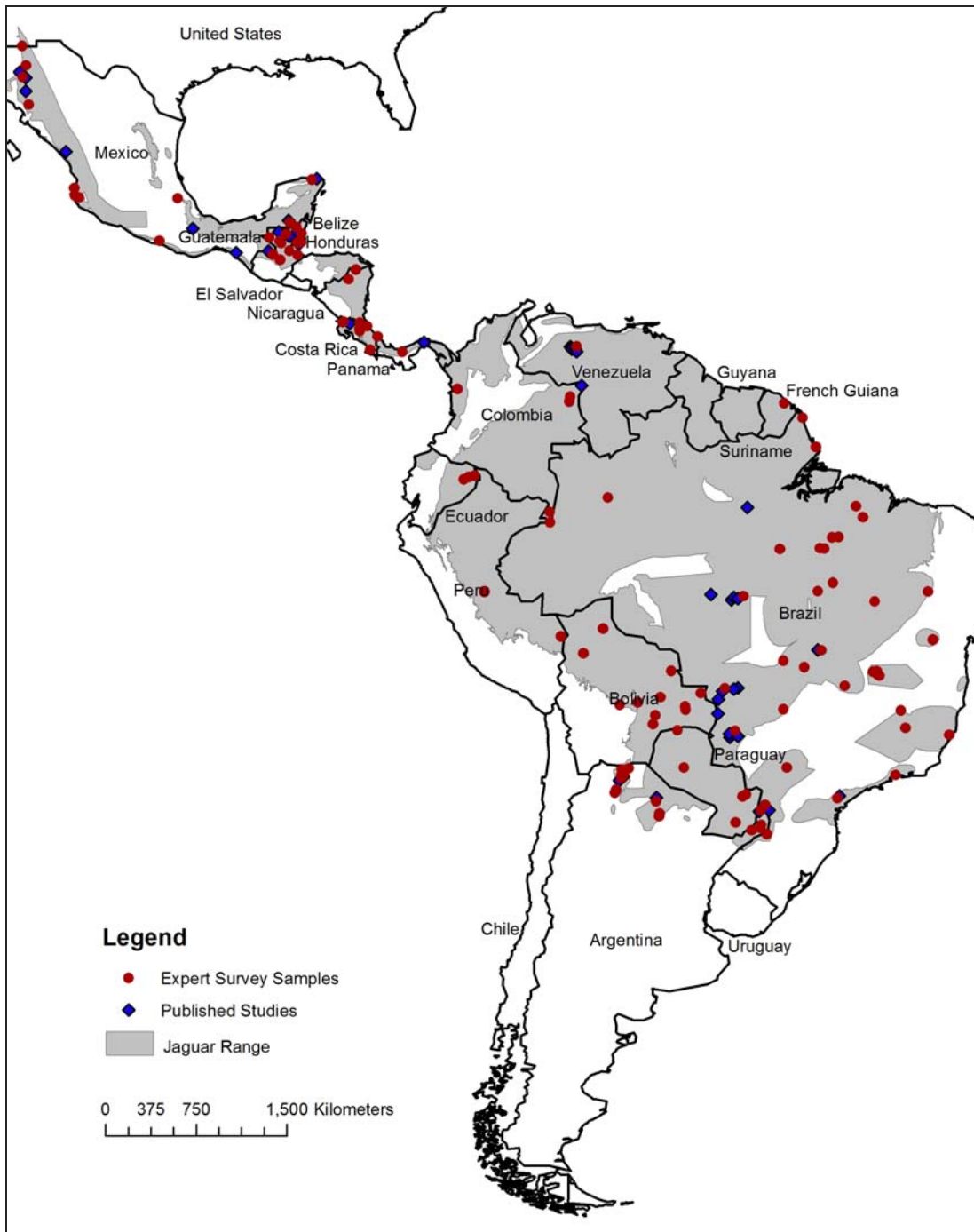
Table 1: Distribution of expert responses, also showing proportions of jaguar range per country.

Literature Review: We reviewed 43 peer-reviewed publications (31 journal papers and 12 book chapters) published between 1986 and 2013. Around half (16) of the journal papers were published in *Oryx* and *Biological Conservation*, and the remainder in 14 other journals. The studies were carried out in only 9 of the 18 jaguar range countries, with the majority of research locations in Brazil (40%) and Mexico (23%). Over half (58%) of studies focused just on the jaguar, while the remainder included its sympatric Puma. The most common research methods were questionnaire surveys and participant observation (63%), assessment of farm records (35%) and field verifications of losses (40%), but telemetry, camera trapping, and faecal analyses were also used for determining predation patterns.

Expert Survey and Literature Review: To explore the spatial characteristics of all the information gathered, we had asked experts to give geographic descriptions, and for the literature samples we used the spatial information provided. **Map 1** shows the locations of all 160 data source included. Of the expert survey cases, 68% were reported to occur inside or at the edge of a protected area, and 44% inside Jaguar Conservation Units (JCU, areas with viable jaguar populations, see Glossary). Of the literature samples, 65% of studies took place inside JCUs, and 65% outside protected areas. In both the survey and the literature, the majority of conflict cases are in tropical moist lowland forest (49% survey, 44% literature), and herbaceous lowland grassland (26% survey, 35% literature) (**Table 2**).

JGR Type	Total area in jaguar range (km ²)	Proportion of the jaguar range	Expert survey locations	Literature study locations
Tropical Moist Lowland Forest	6,057,396	38.35%	57	19
Tropical Moist Montane Forest	1,163,561	7.37%	10	5
Tropical Dry Forest	3,659,781	23.17%	31	4
Xeric	1,951,645	12.36%	3	4
Herbaceous Lowland Grassland	1,870,664	11.84%	10	15
Herbaceous Montane Grassland	703,648	4.46%	0	0
Temperate Forest	313,010	1.98%	5	3
Mangrove	73,641	0.47%	1	0
Sums	15,793,346	100%	117	50*

Table 2: Occurrence of jaguar conflicts from the survey and literature in each of the *Jaguar Geographic Regions* as defined by Sanderson et al. (2002). *A few of the 43 publications had more than one study site, e.g. Marchini & Macdonald (2012)



Map 1: Map showing locations of 117 cases of conflict described by expert survey respondents (red circles), and 43 studies reported in the literature (blue diamonds). Mapped in ArcGIS v10.1

Socio-Economic Contexts

Expert Survey: In our survey, the majority (40%) of described cases involved long-resident, multi-generational cattle ranchers, followed by recent or new settlers from other areas (23%) and indigenous communities (21%), while the remainder (15%) involved companies and other types of cultural background. The distribution of land tenure situations of the communities described was as follows: 57% were land owners, 6% had long-term leases, 11% had indigenous land rights, 9% were new or migrant settlers, 5% were illegal settlers, and 12% had other forms of land tenure.

The typical land sizes in the described communities in the described conflict cases were mostly small: 51% were small-scale or subsistence livestock keeping/herding or with just occasional livestock kept (land sizes under 100 ha), 22% were medium-sized cattle/livestock operations (under 1,000 ha), 15% were large-scale professional or traditional livestock ranching (10,000 ha or larger), and 13% were used for other purposes.

Literature Review: The geographic scales and contexts of the published studies varied and included community areas, single cattle ranches of 10,000 ha to 80,000 ha, to national surveys of areas up to two million km² (**Table 3**). Around half of the studies were carried out in the extensive cattle ranching regions of the Brazilian Pantanal, the Venezuelan Llanos and the Mexican Sonora (Quigley & Crawshaw, 1992; Hoogesteijn et al., 1993; Dalponte, 2002; Hoogesteijn et al., 2002; Lopez-Gonzalez & Lorenzana-Pina, 2002; Polisar et al., 2003; Azevedo & Murray, 2007a; Azevedo & Murray, 2007b; Hoogesteijn & Hoogesteijn, 2008; Rosas-Rosas et al., 2008; Cavalcanti & Gese, 2010; Cavalcanti et al., 2010; Rosas-Rosas & Valdez, 2010; Zimmermann et al., 2010a; Cavalcanti et al., 2012a; Cavalcanti et al., 2012b; Marchini & Macdonald, 2012).

The other half were studies in settings of smallholdings or mixed farming communities, often at protected area edges, and the studies tended to focus on many small farms or villages across study area regions varying from around 20,000 ha to entire states (Rabinowitz, 1986; Perovic & Herran, 1998; Perovic, 2002; Schiaffino et al., 2002; Vidolin et al., 2004; Navarro-Serment et al., 2005; Altrichter et al., 2006; Michalski et al., 2006; Palmeira & Barrella, 2007; Moreno & Olmos, 2008; Boulhosa & Michalski, 2009; Carvalho & Pezzuti, 2010; Cruz et al., 2011; Figel et al., 2011; Navarro-Serment et al., 2011; Soto-Shoender & Giuliano, 2011; Torres & Ramos-Fernández, 2011; Garrote, 2012; Palmeira & Trinca, 2012; Amador-Alcala et al., 2013; Amit et al., 2013; Soto-Shoender & Main, 2013).

Reference ⁽¹⁾	Country	Location ⁽²⁾	Scale of Study Area	Habitat Type ⁽³⁾	Protected area	JCU	Corridor	Cattle density	Human density
Perovic 2002	Argentina	Salta & Jujuy	region	Montane	outside	inside	outside	<7.5	2-20
Schiaffino et al 2002	Argentina	Iguazú	region	Tropical Forest	edge	inside	outside	<7.5	20-50
Altrichter et al 2006	Argentina	Salta, Formosa, Chaco, Santiago del Estero provinces	region	Dry Forest	outside	edge	inside	15-100	0-5
Perovic & Herran 1998	Argentina	Salta & Jujuy	region	Montane	outside	inside	outside	<7.5	2-20
Rabinowitz 1986	Belize	Cockscomb Basin	region	Tropical Forest	edge	inside	outside	<7.5	10-20
Miller 2002	Belize	Gallon Jug	1 ranch (52,000ha)	Tropical Forest	inside	inside	outside	<7.5	5-10
Quigley & Crawshaw 1992	Brazil	Pantanal (Mato Grosso do Sul)	region	Grassland	outside	inside	outside	7.5-50	0-2
Dalponte 2002	Brazil	Faz. Sta Ines & Faz. Baia Dom Bosco, Pantanal (MS)	2 ranches (39,000ha)	Grassland	outside	inside	outside	7.5-15	0-2
Conforti & Azevedo 2003	Brazil	Iguaçu	region	Tropical Forest	edge	inside	outside	<50	20
Vidolin et al 2004	Brazil	Parana	state-wide	Tropical Forest, Temperate	outside	outside	outside	7.5-50	5-50
Zimmermann et al 2005	Brazil	Pantanal (Mato Grosso)	50 ranches (average 12,950ha)	Grassland	outside	inside	outside	7.5-50	0-2
Michalski et al 2006	Brazil	Alta Floresta, Mato Grosso	236 farms (16-26,000ha)	Tropical Forest	outside	outside	outside	7.5-50	0-5
Azevedo & Murray 2007a	Brazil	Fazenda San Francisco, Pantanal, Mato Grosso do Sul	1 ranch (15,000ha)	Grassland	outside	inside	outside	15-50	2-5
Azevedo & Murray 2007b	Brazil	Fazenda San Francisco, Pantanal, Mato Grosso do Sul	1 ranch (15,000ha)	Grassland	outside	inside	outside	15-50	2-5
Palmeira & Barella 2007	Brazil	Iporanga, Vale do Ribeira, São Paulo	two communities (9,600ha)	Temperate	edge	inside	outside	<1	2-5
Palmeira et al 2008	Brazil	Fazenda Ouro Branco, Bonópolis, Goiás	1 ranch (20,000ha)	Dry Forest	outside	outside	outside	15-100	0-2
Carvalho & Pezzuti 2010	Brazil	Tapajós-Arapuins Extractive Reserve, Amazon	45 villages (region of 650,000ha)	Tropical Forest	inside	outside	outside	<7.5	0-2
Cavalcanti & Gese 2010	Brazil	Fazenda Sete, Pantanal (Mato Grosso do Sul)	1 ranch (46,000ha)	Grassland	outside	inside	outside	7.5-50	<5
Cavalcanti et al 2010	Brazil	Pantanal (MS & MT) & Alta Floresta	region	Tropical Forest, Grassland	outside	outside	outside	7.5-50	0-10
Cavalcanti et al 2012	Brazil	Fazenda Sta Tereza, Pantanal (Mato Grosso do Sul)	1 ranch (63,000ha)	Grassland	outside	inside	outside	7.5-50	<5
Marchini & Macdonald 2012	Brazil	Pantanal (MT) & Alta Floresta	region	Tropical Forest & Grassland	outside	outside	outside	7.5-50	0-10
Palmeira & Trinca 2012	Brazil	Juruena National Park (Mato Grosso)	35 farms near the PA	Tropical Forest	edge	edge	outside	<7.5	0-2
Bolhousa & Michalski 2009	Brazil	Alta Floresta (Mato Grosso)	236 ranches in region, range 16-26,000ha	Tropical Forest	outside	outside	outside	7.5-50	0-5
Garrote 2012	Colombia	Municipio de Puerto Carreño, Dept del Vichada, Llanos	large ranching area	Grassland	outside	inside	outside	<7.5	0-2
Amit et al 2013	Costa Rica	Chorotega and Huetar Norte, northern CR	several provinces, large region	Tropical Forest	outside	inside	outside	7.5-50	20-50
Soto-Schoender & Giuliano 2011	Guatemala	Petén district	83 ranches (10ha to >1000ha)	Tropical Forest	outside	outside	outside	<7.5	10-20
Soto-Schoender & Main 2013	Guatemala	Maya Biosphere Reserve, Petén (Uaxactun & Carmelita)	two villages	Tropical Forest	inside	inside	outside	<1	5
Gonzalez & Pina 2002	Mexico	East-central Sonora	region of approx. 50,000ha	Xeric	outside	inside	outside	7.5-15	0-2
Navarro-Serment et al 2005	Mexico	Sinaloa	state-wide	Dry Forest	outside	edge	inside	15-50	2-20
Rosas-Rosas et al 2008	Mexico	NE Sonora	region with 11 ranches (40,000ha)	Xeric	outside	inside	outside	7.5-15	0-2
Rosas-Rosas & Valdez 2010	Mexico	northern Sierra Madre Occidental, NE Sonora	region with 11 ranches (40,000ha)	Xeric	outside	inside	outside	7.5-15	0-2
Cruz et al 2011	Mexico	Santa María & San Miguel Chimalapa, Oaxaca	region	Tropical Forest, Montane, Dry	outside	outside	outside	<15	
Figel et al 2011	Mexico	Chinantla, Sierra Norte, Sierra Madre Oriental, Oaxaca	region	Montane	outside	outside	edge	<7.5	10-20
Navarro-Serment et al 2011	Mexico	Yum Balam, Quintana Roo	region	Tropical Forest	edge	inside	outside	<7.5	2-5
Torres & Ramos-Fernandez	Mexico	El Triunfo & La Sepultura Biosphere Reserves	region	Tropical Forest, Montane	edge	outside	outside	<7.5	20-50
Amador-Alcala 2013	Mexico	Montes Azules & Calakmul Biosphere Reserves	region	Tropical Forest	edge	inside	outside	<7.5	10-20
Moreno & Olmos 2008	Panama	Parque Nacional Portobelo, Colon	36,000ha PA	Tropical Forest	inside	inside	outside	<15	25-50
Hoogesteijn et al 1993	Venezuela	Llanos	3 ranches (average 27,000ha)	Grassland	outside	inside	outside	15-100	2-5
Hoogesteijn et al 2002	Venezuela	Llanos	region	Grassland	outside	inside	outside	15-100	2-5
Scognamiglio et al 2002	Venezuela	Hato Piñero, Llanos	1 ranch (80,000ha)	Grassland	edge	inside	edge	15-50	2-5
Polisar et al 2003	Venezuela	Hato Piñero, Llanos	1 ranch (80,000ha)	Grassland	edge	inside	edge	15-50	2-5
Hoogesteijn & Hoogesteijn 2008	Venezuela	Llanos	6 ranches in region	Grassland	outside	inside	outside	15-100	2-5

(1) Excludes studies at national or range-wide scale (i.e. no specific study site): Silveira et al 2008; de Carvalho & Morato 2013; Saenz & Carillo 2002; Rabinowitz 2005; Crawshaw 2003; Jedrejowski et al 2011; Zarco-Gonzalez et al 2013

(2) "Tropical Forest" = Tropical Moist Lowland Forest; "Montane" = Tropical Montane Forest; "Dry Forest" = Tropical Dry Forest; "Temperate" = Temperate Forest; "Grassland" = Herbaceous Lowland Grassland; "Xeric" = Xeric

Table 3: A list of the publications reviewed, with their locations and some geographical variables.

Livestock Depredation

Expert Survey: In our survey, respondents described communities with income sources mostly from livestock (30%) and other forms of agriculture (26%), and to a lesser extent supplemented by crafts (8%), tourism (13%), labour (10%) and other industries (12%). The experts were asked which livestock were kept by the communities they were describing, and which livestock losses were blamed on jaguars. All of the communities which kept cattle also blamed, to some extent, their losses of cattle on jaguars. Losses of dogs, sheep, goats and pigs were also frequently blamed on jaguars (**Figure 2**). The majority (63%) of described farming communities managed their livestock extensively (i.e. free-ranging, where livestock are mostly left to roam large paddocks, with little guarding), the remainder involved intensive husbandry styles (17%) or subsistence-level livestock keeping (19%).

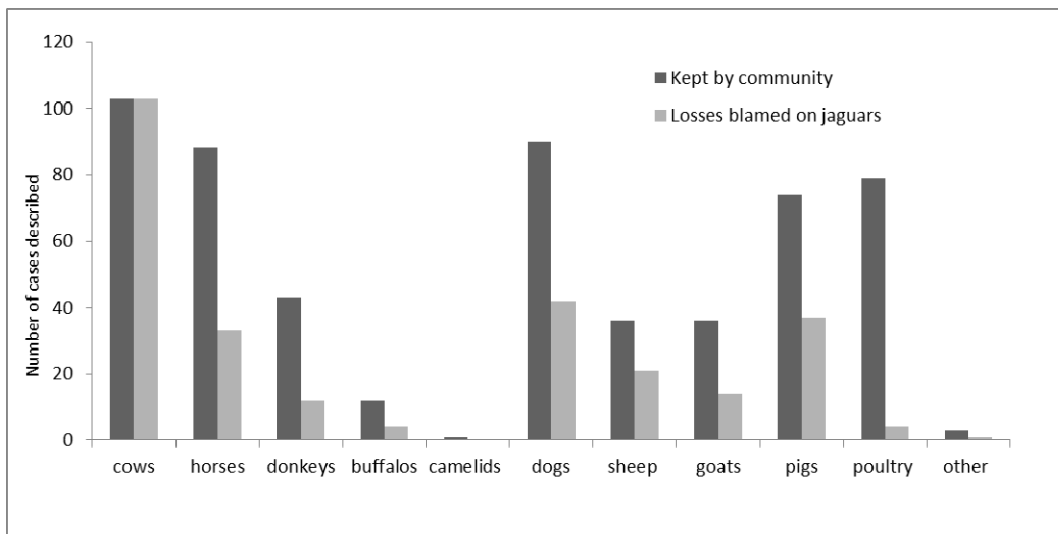


Figure 2: Livestock species kept by communities, and extent to which losses of each of these is blamed on jaguars.

Literature Review: In the literature there are a few studies which report depredation on smaller livestock, for example around Montes Azules and Calakmul Biosphere Reserves in southern Mexico, where sheep, pigs and dogs are the most-attacked domestic animals

(Amador-Alcala et al., 2013), while pigs are the main target in communities in the eastern Colombian llanos (Garrote, 2012). The more common scenario, however, is that jaguars prey on cattle, and the vast majority of studies report patterns of cattle kills, noting that jaguars kill mostly calves (Schaller, 1983; Quigley & Crawshaw, 1992; Hoogesteijn et al., 1993; Polisar et al., 2003; Michalski et al., 2006; Azevedo & Murray, 2007a; Hoogesteijn & Hoogesteijn, 2008; Palmeira et al., 2008; Rosas-Rosas et al., 2008; Cavalcanti & Gese, 2010; Soto-Shoender & Giuliano, 2011).

In cattle ranching areas, the extent to which farms are affected by jaguar predation tends to be widespread – e.g. 82% of ranchers reported depredation problems in the northern Pantanal of Brazil (Zimmermann et al., 2005) with similar findings of widespread depredation in the southern Pantanal (Crawshaw & Quigley, 2002; Cavalcanti & Gese, 2010), whereas in mixed communities, such as in Jalisco, Mexico, depredation affects some farmers much more than others (Nunez et al., 2000).

Documenting actual depredation, rather than that reported by farmers has been done via scat analyses, inspection of carcasses, and telemetry (Azevedo & Murray, 2007a; Azevedo & Murray, 2007b; Cavalcanti & Gese, 2010). Cavalcanti & Gese's (2010) telemetry studies at Fazenda Sete in the southern Pantanal brought valuable insight into the precise feeding habits of 10 collared jaguars. Their study showed that on this large cattle ranch in which both natural prey and cattle were easily available to the cats, jaguar prey on average consisted 68% of native prey, and 32% of cattle. All jaguars killed cattle, but some had more than 50% of cattle in their diet, while others had less than 5%. Some preyed on many different species, while others specialised on just a few (Cavalcanti & Gese, 2010).

Across the species' range, the two principal factors leading jaguars to prey on livestock are widely believed to be depletion of wild prey and poor livestock husbandry practices (Quigley & Crawshaw, 1992; Hoogesteijn et al., 2002; Azevedo & Murray, 2007a; Navarro-Serment et al., 2011; Torres & Ramos-Fernández, 2011; Cavalcanti et al., 2012a).

Livestock husbandry is reported by many authors to be poor and mostly extensive, where cattle are left to roam pastures unguarded, often too close to forest edges or patches. In many cases there is little veterinary care, no breeding strategy, no health plan, and generally very poor management. Losses of stock are most commonly caused by malnutrition, disease and theft, with parasites, rabies from vampire bats, snake bites, toxic plants, lightning, and veterinary malpractice or birth complications also cited as causes of mortality (Schaller, 1983; Quigley & Crawshaw, 1992; Hoogesteijn et al., 1993; Hoogesteijn et al., 2002; Schiaffino et al., 2002; Scognamillo et al., 2003; Vidolin et al., 2004; Navarro-Serment et al., 2005; Altrichter et al., 2006; Palmeira et al., 2008; Rosas-Rosas & Valdez, 2010; Navarro-Serment et al., 2011; Soto-Shoender & Giuliano, 2011; Amador-Alcala et al., 2013)

Conversely, several authors note observations of minimal depredation on cattle ranches where prey is abundant: Azevedo & Murray (2007b) found on a well-managed ranch in the southern Pantanal that although the biomass of livestock was eighteen times higher than that of natural prey (of which there was also an abundance) cattle depredation was negligible. Similarly, at a conservation-friendly cattle ranch in northern Belize, Miller (2002) noted that there had been no losses of livestock at all, due to good husbandry and strict wildlife protection. Polisar et al., (2003) reported the same pattern from their work in the llanos of Venezuela.

Natural prey levels and husbandry practices therefore seem to be the most important drivers of conflict. Some additional factors may influence the predation habits and behaviour of individual cats: Rabinowitz (1986) reported his frequently-cited observation that a significant number of livestock-predating jaguars had injuries (such as shotgun wounds or broken canines); but subsequent studies noted that entirely healthy jaguars, too, prey on cattle, e.g. Lopez-Gonzalez & Lorenzana-Piña (2002). Several authors suggest that because jaguar cubs learn their hunting skills from their mother, a livestock-raiding female is likely to pass such habits on to her offspring (Quigley & Crawshaw, 1992; Hoogesteijn et al., 1993; Polisar et al., 2003).

Spatial and temporal patterns of depredation vary across the range and tend to be specific to individual ranches or communities. However, a recurring observation in the literature is that depredation mostly occurs away from houses and in pastures near forest patches within them and/or close to riparian forests and permanent water sources (Quigley & Crawshaw, 1992; Vidolin et al., 2004; Michalski et al., 2006; Soto-Shoender & Giuliano, 2011; Amador-Alcala et al., 2013). Seasonal patterns are less prominent, but the rainy season is the most commonly observed time of year for jaguar depredation in Venezuela, Brazil, Guatemala and Costa Rica (Saenz & Carrillo, 2002; Polisar et al., 2003; Hoogesteijn & Hoogesteijn, 2008; Palmeira et al., 2008; Soto-Shoender & Giuliano, 2011).

Even within known hotspots of human-jaguar conflict, depredation doesn't affect all farmers equally (Soto-Shoender & Giuliano, 2011). Farms close to protected areas were observed to be more affected in Costa Rica, where 87% of attacked cattle farms were less than 15km from a protected area (Saenz & Carrillo, 2002).

The economic impacts of depredation are most often calculated based on ranchers' own reports and/or their livestock inventories. Findings calculated as proportions of livestock holdings include: 0.8% and 0.6% on two different ranches in the Pantanal (Dalponte, 2002; Azevedo & Murray, 2007a), 0.4% around Iguazu (Conforti & de Azevedo, 2003), 0.7% in Petén (Soto-Shoender & Giuliano, 2011), 0.4% in the Cerrado (Palmeira et al., 2008), 1.8% in the Venezuelan llanos (Scognamillo et al., 2002) and 1.4% in the Colombian llanos (Garrote, 2012).

Severity, attitudes and persecution of jaguars

Expert survey: In the survey, the frequency of depredations across all of the cases were categorised by the experts as: 32% frequent (many times per year), 47% occasional (once or twice a year), 14% rare (less than once a year), 7% unknown. There were no significant correlations between the reported frequency of attacks and other reported variables such as: persecution of jaguars, community tolerance levels, access to third-party assistance, proximity to protected areas, or prey or habitat quality.

In 66% of the described cases, community members believe that jaguars sometimes also attack people, and in those communities holding this perception people have lower tolerance levels ($r_s = -0.294$, $n = 105$, $p < 0.01$). The experts stated that hunting or persecution of jaguars is known to occur in 70% of described cases, and they considered it 'likely' in a further 23%.

We asked the experts to give an indication of how severe *they* consider conflict cases to be (i.e. not how farmers consider them): they considered the described scenarios *for jaguars* to be mostly 'very serious' ("a major problem for the conservation for jaguars in this

region”) but *for people* mostly ‘moderately serious’ (“a concern for this community, but there are other more serious problems” (**Figure 3**). There was no correlation between perceived severity for jaguars and for people ($r_s=-0.151$, $n=113$, $p=0.110$, NS).

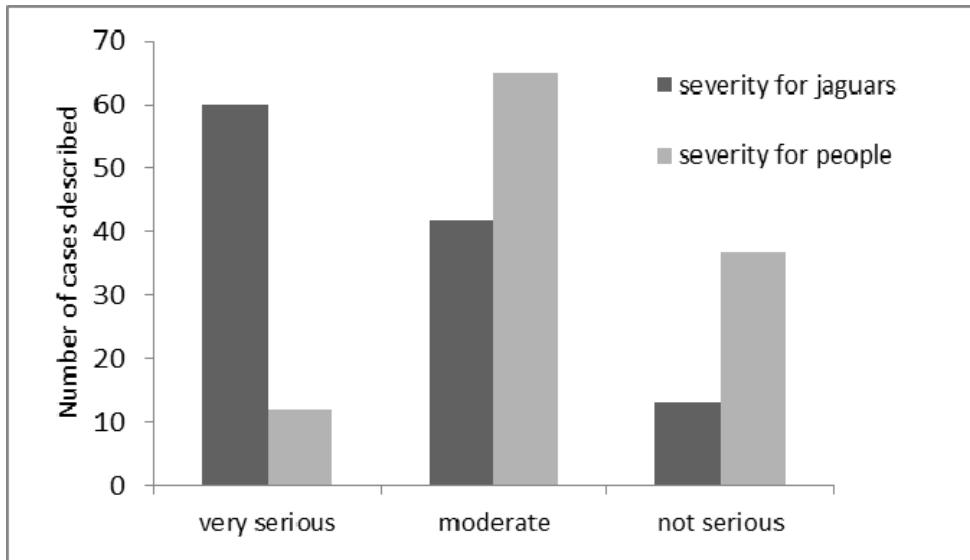


Figure 3: Experts’ perception of the severities of conflict cases for jaguars and for people

To identify the most serious cases of human-jaguar conflict across the range (based on the information given by our experts) we scored the variables *frequency of depredation*, *persecution of jaguars*, *severity for jaguars*, *severity for people*, *third party intervention*, *tolerance levels*, and *quality of prey and habitat*. **Table 4** lists the 20 most serious locations of human-jaguar conflict reported by our 117 surveyed experts.

The described cases with the highest severity *for jaguars* were those in which tolerance was lowest ($r_s=-0.307$, $n=114$, $p < 0.001$), and those with the highest severity *for people* were located inside or at the border of protected areas ($r_s=0.199$, $n=114$, $p < 0.05$). Severity for people was not correlated with tolerance, nor with access to third-party assistance. Severity for jaguars was not correlated with proximity to protected areas, but was worst in locations with poor prey base ($r_s=0.251$, $n=111$, $p < 0.01$) and poor habitat quality ($r_s=0.262$, $n=113$, $p < 0.01$).

Country	Community / Location	Frequency of depredation	Persecution of jaguars	Severity for Jaguars	Severity for People	Third party intervention	Tolerance	Prey base	Habitat quality
Argentina	Kollas & Guarani communities, Yungas Biosphere Reserve	frequent	yes	serious	moderate	no	low	poor	poor
Argentina	Normenia, Jujuy	occasional	probably	serious	moderate	no	medium	poor	poor
Argentina	San Andres, Salta	occasional	probably	serious	moderate	no	medium	poor	poor
Bolivia	Estancia ganadera colindante al Parque Nacional Kaa Iya	frequent	yes	serious	not serious	no	low	poor	medium
Bolivia	Estancia ganadera San Luis, Santa Cruz	occasional	probably	serious	moderate	yes	low	poor	poor
Bolivia	Estancia ganadera San Miguelito, Chiquitania	frequent	yes	serious	not serious	yes	low	medium	poor
Bolivia	Isozo indigenous territory, west of Kaa-Iya del Gran Chaco National Park	occasional	yes	serious	serious	no	low	medium	good
Brazil	Município de Pequiçeiro, Tocantins	frequent	yes	serious	moderate	yes	low	poor	poor
Brazil	Ranchers in the southern Pantanal (Mato Grosso do Sul)	frequent	yes	serious	not serious	no	low	poor	poor
Brazil	Lago Piratuba, município de Pracuba, Amapá	frequent	yes	serious	not serious	yes	low	poor	poor
Brazil	Fazendeiros da região de Luziânia (Goiás)	occasional	yes	serious	moderate	no	low	poor	medium
Brazil	Amazon frontier, Alta Floresta and Novo Mundo (Mato Grosso)	rare	yes	serious	serious	no	low	medium	poor
Brazil	Fazendeiros, município de Bonópolis (Goiás)	frequent	yes	serious	moderate	yes	low	good	poor
Brazil	Entorno do Parque Nacional da Serra do Cipó, Minas Gerais	occasional	yes	serious	moderate	no	medium	poor	medium
Brazil	Município de Sao Felix do Xingu, Pará	frequent	yes	serious	serious	no	high	good	poor
Colombia	Guahibo, Vichada district, Llanos	occasional	yes	serious	moderate	yes	low	poor	medium
Costa Rica	Boca de San Carlos, San Carlos-Alajuela	occasional	yes	serious	moderate	yes	low	poor	poor
Guatemala	Petén, La Libertad	occasional	probably	serious	serious	yes	low	medium	poor
Mexico	Comunidad indígena de Santa Cruz del Tuito	frequent	yes	moderate	moderate	no	low	poor	poor
Mexico	Nacori Chico, Sonora, Sierra Madre Occidental	occasional	probably	serious	moderate	no	medium	poor	poor
Paraguay	Chaco region of northern Paraguay	frequent	yes	serious	serious	no	medium	medium	good

Table 4: The 20 most serious locations of human-jaguar conflict reported experts.

Scores: Frequency of depredation: frequent (3), occasional (2), rare (1); Persecution of jaguars: yes (3), probably (2), unlikely (1); Severity for Jaguars: serious (3), moderate (2), not serious (1); Severity for People: serious (3), moderate (2), not serious (1); Third party intervention: yes (0), no (1); Tolerance: high (1), medium (2), low (3); Prey base: good (1), medium (2), poor (3); Habitat quality: good (1), medium (2), poor (3).

Experts considered persecution to be highest in places where conflicts were most severe both for jaguars ($r_s=0.205$, $n=114$, $p < 0.05$) and for people ($r_s=0.240$, $n=112$, $p < 0.05$). However, persecution levels were not correlated with tolerance levels, third party assistance, or proximity to protected areas. Tolerance levels among the sampled communities were medium to low: 51% fell into the description of “accept value of jaguars

but unhappy about losses” and 43% were described as “do not want to co-exist with jaguars at all”.

Literature Review: In the literature, observations about tolerance are widely discussed. Cavalcanti & Gese (2010) describe the perception in the Pantanal: “Ranchers believe they are unfairly burdened with high losses of cattle due to jaguar predation.” Depredation is perceived as a major threat by ranchers, is widely overestimated, and used as justification for killing jaguars (Cavalcanti & Gese, 2010). In small or mixed farming communities (e.g. in Oaxaca and Amazonia) such persecution is mostly opportunistic, while on traditional large cattle lands (e.g. Sonora, Llanos, Pantanal) ranchers may actively hunt jaguars (Quigley & Crawshaw, 1992; Hoogesteijn et al., 2002; Azevedo & Murray, 2007b; Carvalho & Pezzuti, 2010; Rosas-Rosas & Valdez, 2010; Navarro-Serment et al., 2011; Torres & Ramos-Fernández, 2011; Cavalcanti et al., 2012a).

Although it is difficult to know exactly how many jaguars are killed, a few reports confirm this issue to be a serious threat to the species: Conforti & de Azevedo (2003) report that 30 jaguars were killed in a two year period (1995-1997) inside Iguazu National Park, Carvalho & Pezzuti (2010) reported 32 jaguars killed over 10 years in an extractive reserve in central Amazonia, Rosas-Rosas & Valdez (2010) reported 11 jaguars killed in three years in the Sonora, Moreno & Olmos (2008) wrote of 17 jaguars killed over a 12-year period in Panama, and of individual ranchers boasting to have killed more than 20 jaguars. Baiting with neurotoxic pesticides around Juruena National Park in Nova Bandeirantes (southern Amazon) raised concern with Palmeira & Trinca (2012) who found four poisoned jaguars on three ranches in a three-month survey. In his study of the Colombian Llanos, Garrote (2012) reported that 42% of ranchers killed jaguars, while an earlier study in the Pantanal suggested that 88% of ranchers killed jaguars (Zimmermann et al., 2005). A survey of

protected area officers across Brazil determined that jaguars are hunted in 43% of Brazilian reserve that contain jaguars, and that the main reason for this was retaliation for depredation, followed by a perceived risk to humans (Carvalho, 2013).

Studies show repeatedly that jaguars are blamed for livestock losses even in cases when it is much more likely that the damage was caused by pumas (Altrichter et al., 2006; Palmeira et al., 2008; Soto-Shoender & Giuliano, 2011). Although it is possible to identify jaguar vs puma kills (for descriptions see e.g. Marchini & Luciano, 2009), ranch hands and farmers often have poor knowledge about the differences between the species and can't distinguish the kills (Palmeira et al., 2008; Figel et al., 2011)

However, persecution is not directly linked to depredation. Living in close proximity to a large wild cat is disturbing for people (Crawshaw, 2003), and it is fear or tradition, rather than losses of stock, that drives people to kill jaguars (Conforti & de Azevedo, 2003; Zimmermann et al., 2005; Marchini & Macdonald, 2012). Attacks on humans are extremely rare (Conforti & de Azevedo, 2003; Crawshaw, 2003; Crawshaw, 2004), e.g. one such was noted in the Chaco in 1995 (Altrichter et al., 2006), however, the only documented *unprovoked* attack occurred in the Pantanal in 2008 (de Paula et al., 2008). Nevertheless, jaguars are widely perceived as dangerous, and this feeds negative attitudes (Altrichter et al., 2006; Marchini & Macdonald, 2012). The reasons why some people kill jaguars and others do not has been studied in detail by S. Marchini, who explains how attitudes and behaviours relate. Whether or not a person kills a jaguar is determined by not only attitudes, but also subjective norms (social pressure), descriptive norms (social identity), and perceived control over his intentions (Marchini & Macdonald, 2012)

Certain stakeholder groups are more negative than others. In a comparative study of ranchers versus villagers in Peten, Guatemala, Soto-Shoender & Main (2013) found that

villagers were more negative and fearful of jaguars than were ranchers. These differences were not explained by exposure to losses. Pantaneiro ranchers were overall more positive than farmers in the Amazonian agricultural frontier (Marchini & Macdonald, 2012). Furthermore, attitudes towards jaguars may be negative, while attitudes towards conservation in general positive; tolerance of jaguars may be low, even though they are valued as natural heritage (Zimmermann et al., 2005). For some cultures, the jaguar has special value, which explains the attention it receives over the puma, and the strong views sometimes held by communities. This value may be utilitarian, for example, in the Pantanal and similar cattle ranching communities, the killing of a jaguar is ingrained in the local culture as an act of bravery (Cavalcanti & Gese, 2010). In several indigenous cultures jaguars hold spiritual values which deter people from killing them, however, with changes in community composition and dilution of cultural identity, traditional beliefs may become eroded, and jaguars are now killed even among, for example, Chinantec and Mayan communities in Mexico (Figel et al., 2011; Navarro-Serment et al., 2011).

Conflict mitigation

Expert Survey: In our survey, the extent to which the conflict-affected communities received assistance from third parties such as NGOs or local authorities varied from 20% receiving assistance in cases of “problem animals”, 34% potentially benefiting from other conservation-related outreach, and 46% receiving no assistance at all.

When asked about their impression of the quality of habitat and abundance of natural prey for the jaguars, experts’ responses to both questions ranged from poor habitat/prey base to good habitat/prey base, with only very few cases describing extremes of these (**Figure 4**). Prey base and habitat were strongly correlated ($r_s=0.460$, $n=112$, $p < 0.001$).

Literature Review: In the literature, many authors emphasize the importance of prey and suggest that prey depletion is a key exacerbating factor in cases of conflict, and hence recommend the protection of natural prey in conflict areas (Quigley & Crawshaw, 1992; Hoogesteijn et al., 2002; Polisar et al., 2003; Azevedo & Murray, 2007a; Cavalcanti et al., 2010; Navarro-Serment et al., 2011; Torres & Ramos-Fernández, 2011)

The most common recommendation in the literature is that of improving livestock husbandry practices. This is recommended across the range, regardless of socio-economic context, size of farm or type of livestock operation (subsistence or large-scale). Such husbandry improvements would include better veterinary care, focussing on protection for calves, excluding cattle from forest, maintaining distance between calving areas and forest, moving calves out of problem areas and replacing them with bulls, and so forth (Quigley & Crawshaw, 1992; Hoogesteijn et al., 1993; Crawshaw, 2003; Polisar et al., 2003; Palmeira et al., 2008; Rosas-Rosas et al., 2008; Cavalcanti & Gese, 2010; Soto-Shoender & Giuliano, 2011; Amador-Alcala et al., 2013; Amit et al., 2013). The *Manual on the problems of depredation caused by jaguars an pumas on cattle ranches* (Hoogesteijn, 2005) provides specific instructions for cattle management methods that help reduce depredation.

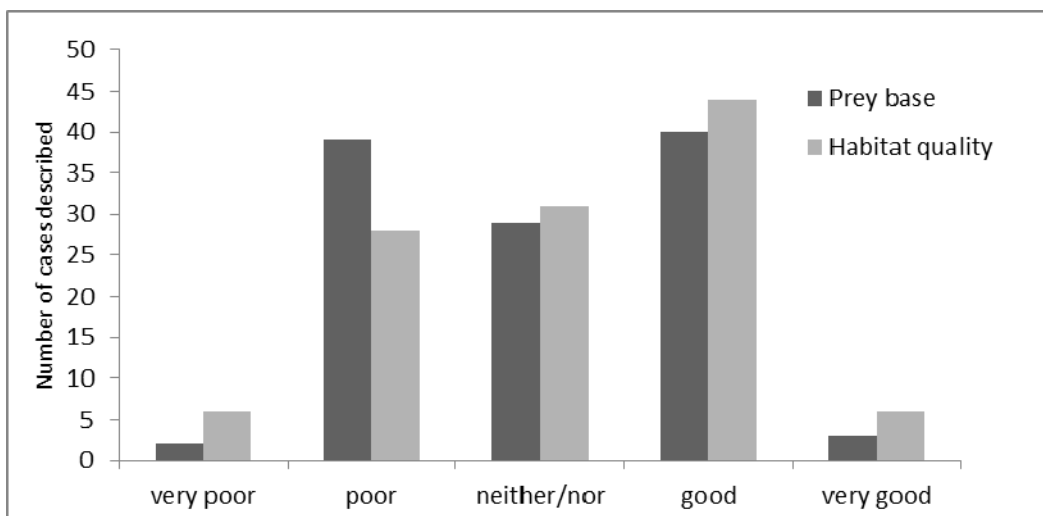


Figure 4: Experts' knowledge of the state of prey availability and habitat quality in the areas of the described cases

In addition to this, a few studies have experimented with electric fencing, with mixed results, noting that success rate is in some cases only 50%, and that it is very expensive (Schiaffino et al., 2002; Scognamillo et al., 2002; Cavalcanti et al., 2012a). Other methods that have been discussed in the literature include the raising of buffalos in addition to cattle (Hoogesteijn & Hoogesteijn, 2008). Translocation of cattle-killing jaguars has also been discussed but deemed unlikely to be good option (Rabinowitz, 1986).

Monetary compensation for livestock losses – as often suggested by ranchers themselves (Crawshaw, 2003; Rosas-Rosas & Valdez, 2010), is an option discussed with much caution by jaguar researchers, who warn about the sustainability of the funds, the logistics of verifying losses, the cost of administration and the risk of fraudulent claims (Conforti & de Azevedo, 2003; Crawshaw, 2003; Cavalcanti & Gese, 2010).

Cultural approaches are advocated by a number of studies, in particular those that have focussed on measuring attitudes such as Zimmermann et al., 2005; Altrichter et al., 2006; Cavalcanti & Gese, 2010. In traditional ranching cultures like the Pantanal, in which industry still revolves around cattle, ranchers may need to accept that cattle are a component of jaguar prey, and the only way to reduce depredation is to improve the protection of cattle. Cavalcanti & Gese (2010) and Quigley & Crawshaw (1992) propose that in this type of culture, such changes are best demonstrated by example rather than imposed.

Discussion

Human-jaguar conflict is a common and widespread threat occurring in all of the jaguar range states. The depletion of wild prey and poor livestock husbandry are widely reported by researchers as the key reasons for depredation, regardless of ecological, cultural and socio-economic contexts.

The combination of expert opinion and systematic review allowed us to gather information from a geographically much larger area than using just one of these methods, and has given us the most comprehensive summary of what we know about human-jaguar conflict to date. Nevertheless the information is clustered, reflecting the distribution of studies to date which have taken place mainly in the Mexican Sonora, Guatemala and Belize, Costa Rica, the Llanos of Venezuela and Colombia, the Brazilian Pantanal, the Amazon frontier particularly in Mato Grosso, Iguazu and Iguazu, northwest Argentina and the Bolivian Chaco and the Chiquitania.

As with many studies in human-wildlife conflict, most research has been in the format of case studies and focussed on quantifying the impacts of depredation. This has given us a good idea of the variety of cases that exist. There appear to be two typical socio-economic scenarios in human-jaguar conflict. One is the cattle ranch context, where farms of several hundred to many thousands of hectares are used for cattle raising, the owners often following a multi-generational tradition of livestock-raising, of the type we find in the Pantanal, the Sonora, the Beni, the Llanos, or the Rupununi. The second is the mixed farm or smallholder scenario, where parcels of land are used both for agriculture and livestock including cows, but also pigs, goats, or sheep, often settled by a variety of communities including migrant settlers and indigenous groups.

The literature also broadly suggests that, across the range and across socio-economic scenarios, two factors that are important in determining human-jaguar conflict are the availability of wild prey, and the quality of livestock husbandry. Looking more closely at the findings of these studies and the opinions of the experts surveyed, we find, however, three important variations:

First, within an area or community, not all farmers are affected equally. The finer-scale patterns of depredation appear to be determined by such factors as how pastures are arranged in relation to forests and water bodies. Second, not all jaguars prey on livestock to the same extent. It depends on behavioural ecology factors such as home range sizes, locations, densities of jaguars, other carnivores and prey (Cavalcanti et al., 2010). Third, not all farmers, even within one community, react the same way, and the proportion of loss certainly doesn't predict their attitudes towards jaguars.

Farmers' economic losses, at whatever scale, also have to be prevented as part of the overall strategy. One simply cannot expect people to accept financial losses and be willing to tolerate carnivores at the same time, regardless of whether it is a rancher losing a small percentage of a ten thousand strong herd of cattle, or a poor farmer losing his only milking cow (Crawshaw, 2003). Thus improvements to husbandry, better protection of livestock and generally increasing the productivity of livestock can do much to ameliorate a conflict in many situations.

Protecting or improving the prey base for jaguars should also lessen depredation in most cases. Yet jaguars were killing cattle on ranches a century ago when prey was certainly more abundant (Im Thurn, 1883; Roosevelt, 1926; Rabinowitz, 2005), reminding us that

depredation can perhaps never be eliminated entirely. Healthy jaguars with access to wild prey will still kill livestock if given a chance (Cavalcanti & Gese, 2010).

Therefore, the key to resolving conflicts is changing what farmers do about it. Critical to this is understanding that attitudes towards jaguars are often not linked to the losses experienced. Marchini & Macdonald (2012) explain this in their comparison of human-jaguar conflict scenarios in the Pantanal and the Amazon: farmers' perceptions and behaviours are determined by a combination of personal motivations, social norms and perceptions of their capacity to act on intentions.

We conclude that human-jaguar conflicts and their resolution hinge on the combination of three critical factors: prey, husbandry and tolerance. We can use the following hypothetical scenarios to illustrate this: 1) in a scenario in which there is *good prey availability, good livestock husbandry, but low tolerance of jaguars*, jaguars probably not prey on livestock as much as elsewhere, but they are still persecuted and there is a risk of local extinction. 2) in a scenario involving *poor prey availability, poor husbandry, and high tolerance* livestock depredation is likely, but the farmer does not retaliate against jaguars. The cats are safe for now, but the situation is inherently risky and unsustainable – for example, a change in farm ownership could easily change this. 3) in a scenario of *good prey availability, good husbandry, and high tolerance*, occasional incidences of depredation could still occur, but these are accepted without retaliation. This is the optimum scenario and the goal of human-jaguar conflict mitigation.

Measures to improve prey and husbandry are therefore certainly crucial and should be implemented everywhere. Protection of prey may require law enforcement and control of hunting, while work with farmers on livestock improvements may take the shape of

developing deterrents, barriers, guarding, and so forth (Crawshaw, 2003) and to this end guides have been produced for farmers, for example in Guatemala and Brazil (Soto et al., 2008b; Soto et al., 2008a; Marchini & Luciano, 2009). But this on its own will not be enough to remedy the threat of conflict for the species. We found that study after study recommends livestock husbandry improvements as a conflict mitigation approach, while at the same time suggesting that attitudes towards jaguars are not linked to losses. This mismatch of endorsing rational solutions while acknowledging that these are not guaranteed to effect behaviour change is critical. We cannot truly progress in resolving human-jaguar conflicts if we do not understand why some conflicts are not resolvable by applying practical solutions. Chapter 5 deals with a discussion of this important issue.

For the jaguar, the majority of work on conflict has been assessments of conflicts, with extensive repetition of study aims and circular citations, agreeing on the same conclusions. Such consensus is certainly promising and positive, but also suggests that the pursuit of many more such quantitative studies may not add much to the collective knowledge. The future of jaguars is overwhelmingly dependent on farmers and their behaviours. While there have not yet been many studies explaining the psychology of conflicts, there are many such studies in related fields (Verissimo, 2013) from which we can borrow an understanding of that we can apply in conservation. For the jaguar, there is an urgent need for action on the ground, (Crawshaw, 2003), a need to deal effectively with the problem in as many locations as possible, starting perhaps with a selection of most serious cases identified by our experts here, and within regions of conflict hotspots (see Chapter 3).

Acknowledgements

We are grateful to the 86 jaguar researchers who contributed their time and knowledge by responding to the survey. Advice and logistical assistance for data collection were provided in particular by Claudio Sillero-Zubiri, Rogerio de Paula and Alan Hesse. Translations into Spanish and Portuguese were by Jose Nuñez-Miño and Silvio Marchini. We are also grateful to Paul Johnson for reviewing manuscript drafts. This project was a collaborative initiative of the Wildlife Conservation Research Unit and Chester Zoo, funded by Chester Zoo.

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A range-wide spatial model of human-jaguar conflict hotspots

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Abstract

The jaguar (*Panthera onca*) occurs across 19 range states, from southern Arizona to northern Argentina. Few pristine areas remain in which jaguars survive undisturbed by human influences. Sixty-five per cent of the remaining 11 million km² jaguar range is outside of protected areas, and it is here that they come into contact with livestock, which often results in retaliatory killing by farmers. Direct persecution of jaguars, as well as the hunting of their wild prey, is the most serious and widespread threat to their survival. By combining geospatial datasets of the jaguar range, protected areas, livestock densities and human geography with expert-based information about jaguar conflicts, we characterised the main spatial patterns of human-jaguar conflicts and present a predictive model of conflict hotspots at a range-wide scale. We found that 85% of the total jaguar range, 72% of the total Jaguar Conservation Units area and 90% of the Jaguar Corridor total area overlaps with livestock to some degree. Using observed patterns of human and cattle densities from 120 examples of human-jaguar conflict, we calculated that 15% of the jaguar range has risk of conflict, and created a map to illustrate risk across the range and specify the key hotspots. Regions in which jaguars are repeatedly persecuted in retaliation for livestock depredation can be likened to ecological traps (unsafe areas with attractive prey, creating a population sink) and may lead to a steady decline of local populations. An awareness of the extent and locations of these conflict risk areas is important in range-wide species conservation strategy and the prioritization of landscape-level concepts such as the Jaguar Corridor Initiative and other efforts outside of protected areas.

Introduction

The jaguar (*Panthera onca*) occurs in 18 range states of mainland Central and South America (all except El Salvador, Uruguay, and Chile), and in southern Arizona, USA. Sanderson *et al.* (2002) calculated that the jaguar survives in nearly 60% of its historic 19.1 million km² range, encompassing 36 ecologically distinct regions. These include habitats as diverse as tropical moist lowland forests, dry forests, xerics, montane forests, grasslands, temperate forests, tropical-wet savannahs and mangroves (Sanderson *et al.*, 2002; Zeller, 2007). Nonetheless, few of the areas in which jaguars remain are fully protected from the threats of human presence. Outside of protected areas, the most common land use in areas occupied by jaguars is livestock ranching, followed by logging, forest matrix lands, and agriculture (Zeller, 2007). The direct persecution of jaguars (most often in retaliation for livestock depredation), and the hunting of their prey is, according to 130 jaguar experts, the most serious threat to the survival of the species (Zeller, 2007). Human-jaguar conflicts are widespread and have been documented in all range states e.g.: (Rabinowitz, 1986; Crawshaw & Quigley, 1991; Dalponte, 2002; Saenz & Carrillo, 2002; Schiaffino *et al.*, 2002; Conforti & de Azevedo, 2003; Polisar *et al.*, 2003; Scognamillo *et al.*, 2003; Michalski *et al.*, 2006; Azevedo & Murray, 2007a; Palmeira *et al.*, 2008).

For the conservation of wide-ranging carnivores, the spatial relationship of protected areas and non-protected areas is important. Protected areas provide safe core areas (ecological sources) while non-protected areas usually form the majority of the total habitat area and provide essential connectivity between the sources. The edges of protected areas are usually high-risk areas for conflict, and can even become ecological sinks. For most species the strongest predictor of extinction risk is the overall size of a species' range (Purvis *et al.*, 2000), but for large carnivores, edge effects are more important than the total range size,

and addressing persecution is the most urgent issue for their conservation (Woodroffe, 2001).

For a widespread species like the jaguar, which will have to exist outside protected areas, planning at the range-wide scale is necessary to ensure its survival in as many different ecological regions as possible (Sanderson et al., 2002; Zeller, 2007). At this scale it is possible to visualize patterns of current and emerging threats and incorporate these into conservation planning and prioritization (Zeller & Rabinowitz, 2011). Such analyses have been carried out for various species, including tigers (Wikramanayake et al., 2004), cheetahs and wild dogs (Durant, 2007).

The jaguar is particularly suited for range-wide planning because it has no subspecies and readily disperses across different areas of its range (Eizirik et al., 2001). The initial jaguar landscape analysis published by Sanderson *et al* (2002), and its updated, freely available dataset by Zeller (2007), led to extensive landscape connectivity analyses and the definition of the Jaguar Corridor by Rabinowitz & Zeller (2010). Our work builds on these milestone studies and takes the next step of examining the most urgent threat to jaguars across the range: conflict with people.

A predictive map of human-jaguar conflict would ideally take account of a diversity of factors known to influence the likelihood of depredation. These would include ecological parameters such as jaguar densities, proximity to protected areas and/or jaguar population source areas, quality of the prey base and the habitat, distribution of water sources, landcover, and the density and distribution of livestock. To this one would add human parameters, including population density, human influence levels, extent of degradation of protected areas and/or jaguar source population areas, land tenure, migration, economic

dependence on livestock, relative wealth, and the extent of third-party assistance for livestock losses.

At the local level, this information can be assembled with considerable effort. Spatial analyses of human-wildlife conflicts at local scales, using empirical data from actual, recorded incidences of conflict and assessing them against a range of covariates, have been carried out for a number species, including elephants in Kenya and India (Sitati et al., 2003; Wilson et al., 2013) wolves in North America (Treves et al., 2004), and jaguars in Mexico (Zarco-Gonzalez et al., 2012).

At the range-wide scale however, such depth of analysis is not practicable, because there are very few variables for which methodologically standardised spatial data are available to be incorporated at this level. Furthermore, many of the variables explored in spatial studies by some authors (Rabinowitz & Zeller, 2010; Zarco-Gonzalez et al., 2012) such as vegetation type, elevation, land cover and roads, are of limited use for the range-wide modelling of conflicts. While at the farm or community level, finer variations in the likelihood of livestock predation exist and tend to be linked to factors such as proximity of the livestock to riverine forests (Palmeira et al., 2008), Zimmermann, unpubl data), at the range scale, depredation could occur in any place that has a sufficient population of jaguars, overlapping with livestock in areas of low human density (as jaguars tend to avoid populated human settlements, Altrichter et al., 2006)). Range-wide spatial analysis is therefore inherently much less precise, but it also serves a different purpose: to reveal the extent and prevalence of conflict across the species' entire range and to provide a basis for planning its conservation inside and outside protected areas.

The aim of this study was to explore spatial patterns of human-jaguar conflict on a range-wide scale in relation to patterns of human influences, in order to draw attention to the main areas of current or emerging risk of conflict, for consideration in major jaguar conservation efforts.

Methods

Study area and geodata compilation

Our area of study was defined by the current jaguar range as calculated and mapped by Sanderson *et al* (2002) and Zeller (2007), which extends from approximately 32°N in southern Arizona to 28°S in northern Argentina, and spans 19 range states (the USA, and all Central American and South American countries except El Salvador, Chile and Uruguay). All our spatial datasets used the WGS84 projection (geographic coordinate system) and were processed and analysed in ArcView v10.1 with Spatial Analyst (ESRI Inc., Redlands, CA). We acquired open source GIS layers for protected areas, livestock densities, human geography and jaguar distribution from the sources listed in **Table 1**.

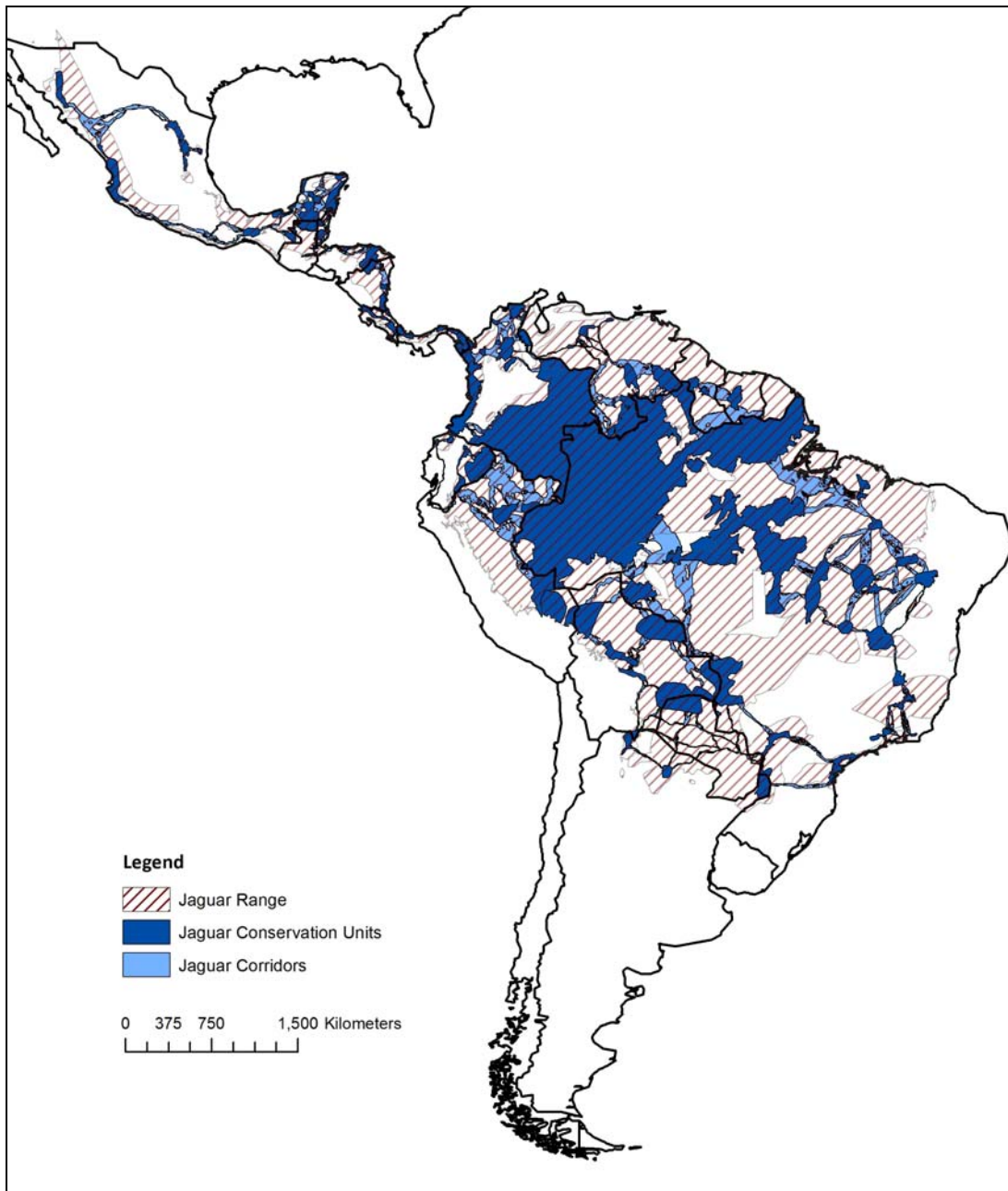
GIS Layer	Dataset name & Citation	Source
Jaguar range	<i>Reported Jaguar Range</i> (updated version by Zeller 2006 Sanderson et al.(2002)	http://www.wcs.org/GISData
Jaguar Corridors	<i>Jaguar Corridors</i> (2013 version by Panthera, unpubl. data, updated from Rabinowitz & Zeller, 2010)	Courtesy of Panthera Landscape Analysis Lab
Jaguar Conservation Units	<i>Jaguar Conservation Units</i> (2013 version by Panthera, unpubl data, updated from Sanderson et al., 2002)	Courtesy of Panthera Landscape Analysis Lab
Protected areas	<i>UNEP-WCMC World Database of Protected Areas</i> (UNEP-WCMC, 2009)	http://sea.unep-wcmc.org/wdbpa
Livestock densities	<i>FAO Gridded Livestock of the World</i> (FAO, 2007)	http://www.fao.org/AG/againfo/re-sources/en/glw/GLW_dens.htm
Human population density	<i>Gridded Population of the World, Version 3 (GPW v3)</i> (CIESN & CIAT, 2005)	http://sedac.ciesin.columbia.edu/data/collection/gpw-v3
Human Footprint Index	<i>Global Human Footprint Dataset</i> (WCS & CIESN, 2005)	http://sedac.ciesin.columbia.edu/data/set/wildareas-v2-human-footprint-ighp

Table 1: Geographic datasets used in this paper.

Jaguar range, Jaguar Conservation Units, and the Jaguar Corridor

The jaguar datasets were created by the Wildlife Conservation Society (WCS) through an expert consultation process with 35 jaguar researchers in 1999 and published by Medellín *et al.* (2002) and Sanderson *et al.* (2002). The WCS dataset was then updated with input from 110 jaguar experts in 2006, published by Zeller (2007). Spatial data from this work are freely available and include the following layers of information: Jaguar Geographic Regions, Extent of Jaguar Knowledge, Jaguar Point Observations, Reported Jaguar Range, and Jaguar Conservation Units. For our analyses we used WCS' dataset of the Reported Jaguar Range (RJR), which is the known currently occupied range, and an updated version of the Jaguar Conservation Units and the Jaguar Corridor created by the Landscape Analysis Lab of *Panthera*, kindly made available to us for this study, which at the time of writing (July 2013) had not yet been released for public use.

Jaguar Conservation Units (JCU) are defined as: “(1) areas with a stable prey community, currently known or believed to contain a population of resident jaguars large enough (at least 50) breeding individuals to be potentially self-sustaining over the next 100 years, or (2) areas containing fewer jaguars but with adequate habitat and a stable, diverse, prey base, such that jaguar populations in the areas could increase if threats were alleviated” (Sanderson *et al.*, 2002). We used these JCUs as a proxy for jaguar abundance at the range-wide scale (**Map 1**).



Map 1: Jaguar range, Jaguar Conservation Units, and the Jaguar Corridor, reproduced from datasets created by Sanderson *et al* 2002, Zeller 2007, and Rabinowitz & Zeller 2010.

Livestock and human geography

The data layer for livestock distribution and density was obtained from the UN Food and Agriculture Organisation via their *Gridded Livestock of the World* dataset (FAO, 2007). For human population density we used the *Gridded Population of the World version 3* (CIESN & CIAT, 2005) and we also downloaded the *Human Footprint Index* dataset, available from the Center for International Earth Science Information Network at Columbia University (WCS & CIESN, 2005)

Protected areas

Spatial data on protected areas were obtained from the World Database on Protected Areas (UNEP-WCMC, 2009) which provides a GIS-compatible layer for mapping the spatial geography of protected areas with associated attribute data, including the size in km² of each protected area. Marine protected areas and sites on offshore islands, which are not within jaguar range, were deleted, as were irrelevant areas such as UNESCO World Heritage Cultural sites. The protected areas data are presented in either point or polygon form, but both had associated attribute data corresponding to area sizes in km², so it was possible to make accurate calculations with these data. For visualisation and modelling purposes however, the protected areas in point-form had to be manipulated in order to produce a final protected area polygon layer for this study. This was done following the same method as Chape et. al. (2005) who extrapolated circular areas from the protected area central point, to create representative polygons. Finally all polygon data were merged, and overlaps removed, to produce a single, terrestrial Latin American protected area polygon layer.

Conflict Samples

We created a layer of human-jaguar conflict samples using the geo-referenced descriptions from our expert-based survey (see Chapter 2). The locations of these 117 described conflict cases collected in the survey were each identified through one of the following sources: a) the expert had provided geographic coordinates, b) the expert was sent a map of the region in a PDF file and asked to mark the locations, c) a publication about the case was available which contained a map or coordinates, d) the location was triangulated by combining place name searches on the internet, Google Earth, and paper maps of the region, and e) locations inside or on the border of protected area were taken from the World Database on Protected Areas.

Risk Modelling

We created three versions of a grid-based index model (at 5x5km, corresponding to the human and cattle density raster datasets), using four spatially explicit parameters: protected areas, Jaguar Conservation Units (JCU), cattle density and human population density. The weightings for cattle and human densities were guided by the patterns of densities observed in the expert-based survey, a systematic review of human-jaguar conflict literature, and case studies of conflict carried out in two other studies (see Chapters 2 and 4). Protected areas and JCUs served as proxies for jaguar presence and we included these and areas up to 30km around them, based on observations by Crawshaw & Quigley (1991) and Crawshaw (1995) that jaguars tend to disperse 30-60km. However, many protected areas in the jaguar range contain no or very few jaguars, which risked exaggerating the hotspots of conflict in many parts of the range. We showed the initial risk map versions to seven jaguar experts with field knowledge of jaguar conflicts in Mexico, Guatemala, Belize, Costa Rica, Brazil, Colombia, Paraguay, and Argentina as well as cross-checking the maps against our own extensive knowledge of many parts of the range.

Using the experts' input, in our final model version any grid cells within 30km of a JCU were included, in three weighting categories (see **Table 2**), and protected areas were removed from the model. Areas with no cattle at all were excluded from the model, and areas with very low ($<7.5/\text{km}^2$) or very high ($>50/\text{km}^2$) cattle densities were weighted lower than values between these. For human population density, areas with zero human presence were excluded, and areas with very low densities ($<5/\text{km}^2$) assigned more weight than those with densities of (5-10/ km^2 or 10-30/ km^2), while areas with more than 30 people/ km^2 were also excluded from the model. The excluded variables were assigned a zero value and the scores multiplied, so that if any grid cell scored a zero in any of the four parameters, this would eliminate it from the model – i.e. it would be considered a non-risk area. We then re-coded the scores into three classes of risk (low, medium, high) and mapped the result, producing a draft range-wide map of human-jaguar conflict risk areas.

Variable, within Jaguar Range	Value	Score	Value	Score	Value	Score	Value	Score
Distance from Jaguar Conservation Unit	0-10 km	3	10.1-20 km	2	20.1-30 km	1	> 30km	0
Cattle density (per km^2)	0.001-7.5	2	7.51-50	3	> 50	2	0	0
Human population density (per km^2)	0.001-5	3	5.01-10	2	10.01-30	1	0, or >30	0

Table 2: Variables included in the spatial model, and their weightings.

Results

The jaguar range in a human-dominated landscape

To verify baseline calculations about the jaguar range we cross-checked our geodata against the WCS Jaguar analyses by Sanderson *et al* (2002) and Zeller (2007). The current extent of the jaguar range is 11,204,249 km², which is 58.8% of its historic range of 19,054,249 km², so the species' range has shrunk by 41.2%. The total extent of mainland terrestrial protected areas within jaguar range (so far as is calculable with the data available) in Latin America is 3,984,041 km², which means that only 35.6% of the jaguar range is within protected areas.

Most (71%) of the jaguar range coincides with very low human population densities of under 5 people/km². For comparison, the Brazilian Pantanal and the Llanos of Venezuela and Colombia, which contain mainly large cattle ranches and good jaguar populations, have human population densities ranging from 1.8 - 2.6 (Swarts, 2000; Rivas et al., 2002). Jaguars also occur predominantly in areas of low Human Footprint Index (an index of the relative human influence in a biome, (WCS & CIESN, 2005): 95% of jaguar range is in areas of an HFI lower than 35, which is comparable to HFI found in the agricultural outskirts of small provincial towns across the continent.

Jaguar predation on livestock predominantly involves cattle, and to a lesser extent sheep, goats and pigs (Chapter 2). Using the *Gridded Livestock of the World* dataset (FAO, 2007) we found that only 0.5% of the Jaguar range is found in areas of cattle densities higher than 15 cattle/km²; the vast majority of the range overlaps with cattle densities of ≤ 7.5 cattle/km². Sheep, goat and pig densities within the jaguar range are extremely low (99.5% of the jaguar range overlaps with ≤ 3 sheep and goats/km² and ≤ 6.2 pigs/km²). However, when all

three livestock groups were combined we found that only 15.4% of the jaguar range has a *zero* density for cattle, sheep, goats and pigs. In other words, almost 85% of the jaguar range has some degree of overlap with livestock, and 45% of the range contains cattle. Ninety per cent of the total area of corridors overlaps with livestock and 39% of corridor area contains cattle. Sixty per cent of the total area of JCU is protected area, 72% and 24% of the total JCU area contains livestock and cattle, respectively (**Map 2**).

Spatial patterns of sampled cases of conflict

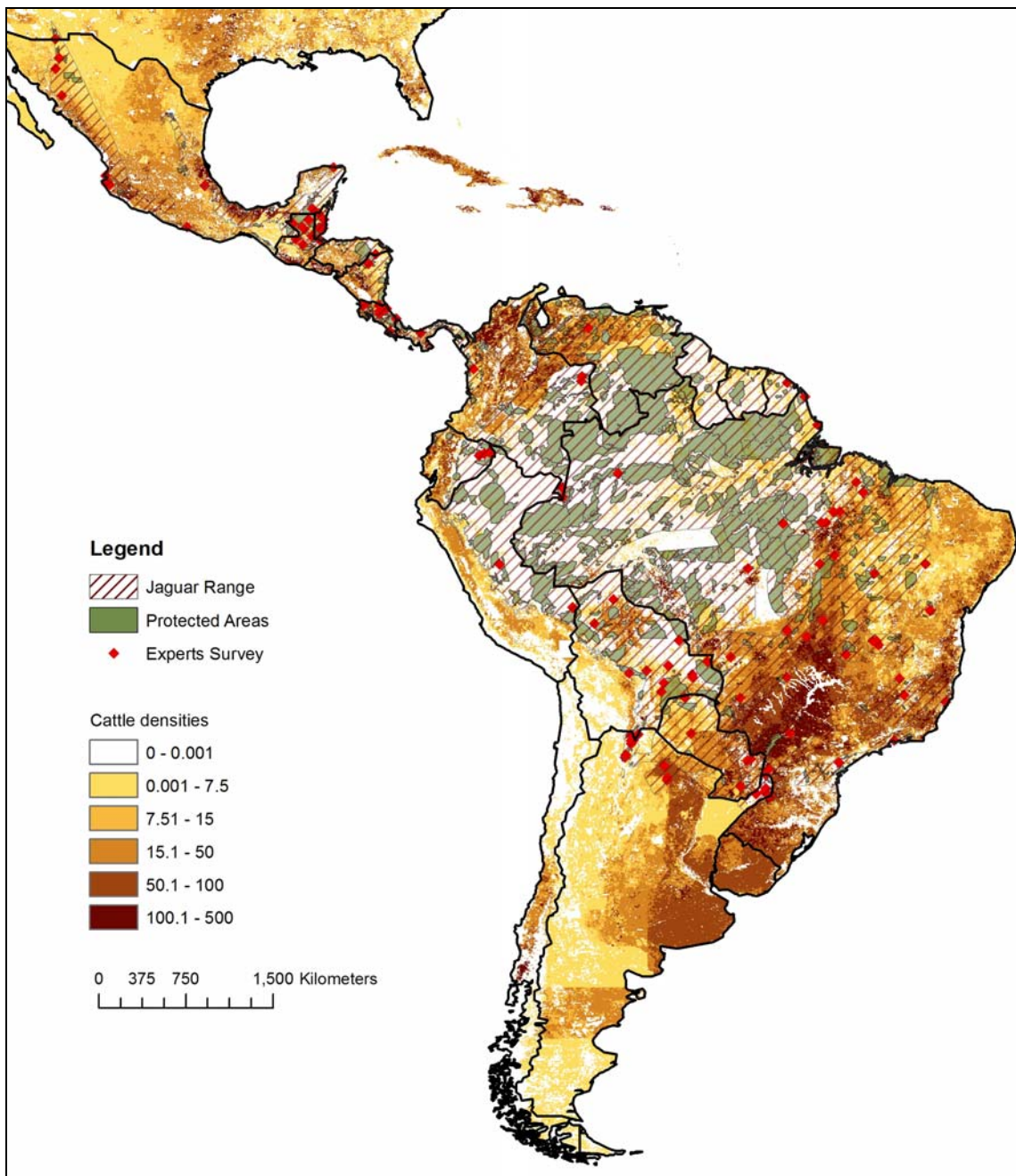
Map 2 also shows the distribution of the 117 described cases of human-jaguar conflict collected in the expert survey. These sample locations are not random (Average nearest neighbour calculation Z-score -9.27), which is a consequence of the expert-based methodology (Chapter 2), because some regions have been studied much more than others. Nevertheless we can observe that 74% of these known conflict locations occur either inside a protected area or within 20km of its edge. Similarly, 44% of conflicts occurred inside JCUs, and 59% inside or within 20km of a JCU edge. We also note that of the conflict cases described, only 12% were at protected areas of IUCN categories Ia (strict nature reserve) or Ib (wilderness areas) and the remainder were at PA categories II-VI, which allow various levels of access or use (national park, natural monument, management area, protected landscape).

Risk model of human-jaguar conflict risk areas

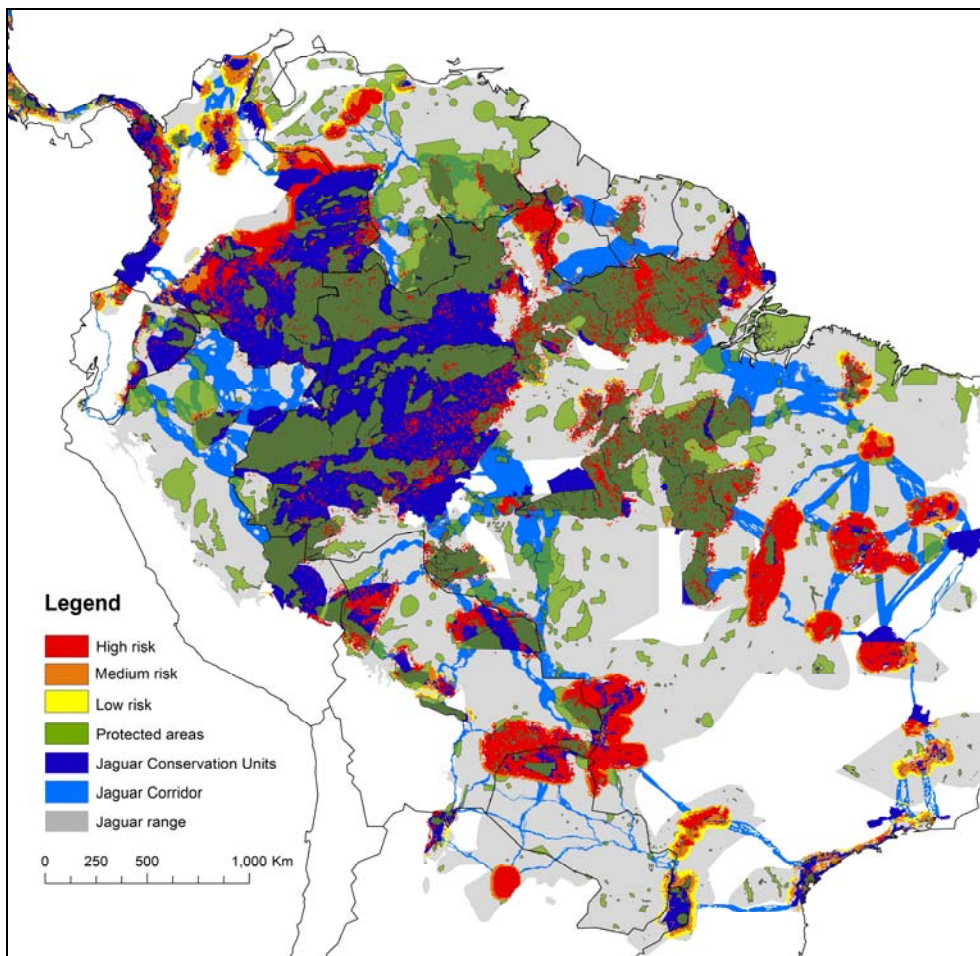
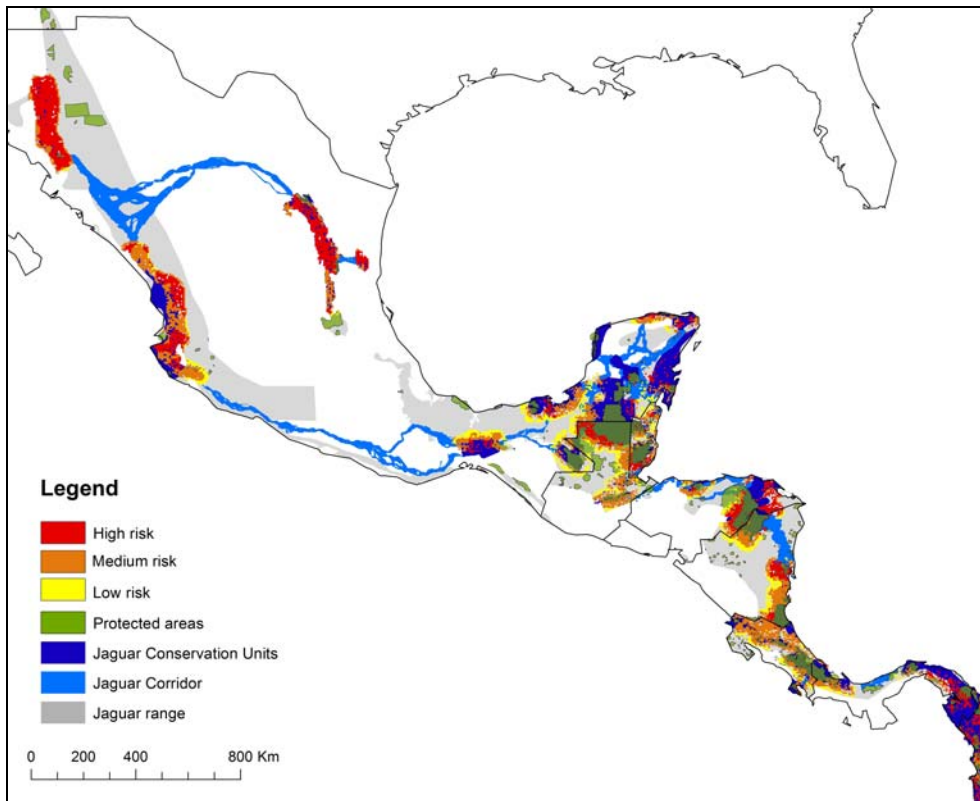
The result of the modelled conflict risk areas, coded into low, medium and high risk levels, is presented in **Maps 3a & b**. Around 15% of the jaguar range contains some risk of conflict (10% high risk, 4% medium risk and 1% low risk). The Jaguar Corridor designed by Rabinowitz & Zeller (2010), which links protected areas and JCUs, appears to avoid conflict risk areas well, as 89% of these corridors are risk-free (with 5% high risk, 4.5% medium risk

and 1.5% low risk). Of the Jaguar Conservation Units, 77% are risk-free, but those that aren't tend to be high-risk (19% of JCU's were high-risk, 4% medium-risk and none low-risk).

Proportional to the jaguar range area they contain, the range states with the most risk of conflict (>20%) were Costa Rica, Belize, Colombia, Guatemala, Honduras and Nicaragua. Those with least risk proportional to their jaguar ranges (<6%) were Peru, French Guiana, Guyana and Suriname. When comparing to the total area of risk across the range, Colombia had a disproportionately large extent of risk (it contains 7.4% of the jaguar range but 14.6% of the risk area), while Peru had the lowest (6.5% of the jaguar range but less than 1% of the risk), see **Table 3**.



Map 2: Protected areas and cattle densities (per km²) across the jaguar range.



Maps 3a & b: Risk of human-jaguar conflict across the range.

Range State	Country Area (km2)	Jaguar Range (km2)	Jaguar Range (% of country area)	Jaguar Range (% of global jaguar range)	Total modelled risk area (km2)	% of country range with low risk	% of country range with medium risk	% of country range with high risk	% of country range with all levels of risk	% of risk in the global jaguar range
Argentina	2,780,991	189,176	6.8%	1.7%	22,675	0.8%	3.3%	7.8%	12.0%	1.6%
Belize	22,093	21,640	97.9%	0.2%	7,475	7.2%	17.0%	10.4%	34.5%	0.5%
Bolivia	1,086,608	754,301	69.4%	6.7%	110,125	0.5%	2.4%	11.7%	14.6%	8.0%
Brazil	8,472,306	6,015,075	71.0%	53.8%	700,425	0.8%	2.3%	8.6%	11.6%	50.8%
Colombia	1,135,171	822,549	72.5%	7.4%	201,350	2.8%	8.8%	12.9%	24.5%	14.6%
Costa Rica	51,078	46,107	90.3%	0.4%	16,775	5.8%	30.5%	0.1%	36.4%	1.2%
Ecuador	255,309	118,408	46.4%	1.1%	17,300	2.7%	5.1%	6.8%	14.6%	1.3%
French Guiana	83,594	83,453	99.8%	0.7%	3,675	0.0%	2.0%	2.4%	4.4%	0.3%
Guatemala	109,023	67,944	62.3%	0.6%	18,050	7.5%	14.2%	4.8%	26.6%	1.3%
Guyana	210,586	210,373	99.9%	1.9%	11,600	0.0%	1.1%	4.4%	5.5%	0.8%
Honduras	112,214	54,270	48.4%	0.5%	13,025	4.1%	8.4%	11.6%	24.0%	0.9%
Mexico	1,956,871	572,435	29.3%	5.1%	112,575	2.8%	7.9%	8.9%	19.7%	8.2%
Nicaragua	128,105	91,248	71.2%	0.8%	18,275	5.9%	9.7%	4.4%	20.0%	1.3%
Panama	74,135	49,783	67.2%	0.4%	9,350	2.7%	7.7%	8.3%	18.8%	0.7%
Paraguay	398,806	398,704	100.0%	3.6%	36,300	0.7%	1.8%	6.6%	9.1%	2.6%
Peru	1,290,857	728,598	56.4%	6.5%	11,350	0.0%	0.3%	1.2%	1.6%	0.8%
Suriname	144,986	144,858	99.9%	1.3%	7,725	0.0%	1.5%	3.8%	5.3%	0.6%
USA	9,465,798	6,222	0.1%	0.1%	-	0.0%	0.0%	0.0%	0.0%	0.0%
Venezuela	910,861	814,411	89.4%	7.3%	60,825	1.1%	2.4%	4.0%	7.5%	4.4%
SUMS	28,689,392	11,189,555			1,378,875					

Table 3: Spatial facts about the jaguar range and risk of conflict for each of the range states.

Discussion

Our analyses show that the majority of the jaguar's remaining range is outside protected areas, and that there is considerable overlap with livestock throughout the range, including within Jaguar Conservation Units and the Jaguar Corridors. When we model areas of potential risk of human-jaguar conflict, our map reveals a number of distinct hotspots, including: the Sonoran rangelands and the forests of Jalisco and Nayarit in western Mexico, parts of the Maya Biosphere Reserve in Guatemala, southern Belize, the Gracias a Dios department in eastern Honduras, around Wawashan and Cerro Silva protected areas in Nicaragua, the Choco-Darien from Panama to Colombia, the Llanos of Colombia and the Llanos of Venezuela, the grasslands of northern Roraima in Brazil and its contiguous Rupununi savannah in Guyana, parts of the Beni and Chiquitania of Bolivia, the Chaco on both sides of the Bolivia-Paraguay border, the Pantanal of Brazil, and areas in the Cerrado and Caatinga biomes in the Brazilian states of Minas Gerais, Goiás, Tocantins, Piauí, Bahia and Maranhão.

The Amazon and the Pantanal are considered to be the two main strongholds for the jaguar (Sanderson et al., 2002). Our model shows virtually all of the Pantanal to be one large hotspot of high risk for conflict, which is widely known to be the case (Rabinowitz, 2005; Zimmermann et al., 2005; Marchini & Macdonald, 2012). In the Amazon, however, we see extensive scatterings of risk rather than distinct hotspots, which appear in and around JCUs that contain low densities of cattle, particularly in parts of Amapá and northern Pará, and south-west of Manaus in Amazonas state. Some of these areas, such as São Felix do Xingú (Pará), the borders of Gurupi Biological Reserve (Maranhão) and Lago Piratuba Biological Reserve (Amapá), and around the Reserva Mamiraua (Amazonas) were confirmed as conflict areas in our expert-based survey (see Chapter 2), but many others are not known to us at this time and must be considered here as likely, but unconfirmed, areas of risk. It

would require extensive consultation with many jaguar researchers *in situ* to validate fully the entire jaguar conflict risk map - a possible next step in this research.

Although nearly half (45%) of the jaguar range contains cattle, the total area of risk is much lower, at 15% of the range, and only 11% of corridor area appears as risky. The locations of the corridors were designed by Rabinowitz and Zeller (2010) as least-cost dispersal routes through which jaguars were most likely to travel safely, based on ecological factors (vegetation types etc.) and human presence (density, roads, etc.) but not cattle – which we found to occur in 39% of the total corridor area. In our model, conflict risk appears very low in corridors because we used JCU as a proxy for jaguar source populations and any point further than 30km from a JCU was excluded from the risk map (52% of the mapped risk is located within JCUs). As a result, any risk within corridors occurs where they intersect JCUs. This most likely does reflect reality, because conflict (characterized by recurring depredation by jaguars coupled with persecution by people) occurs where there is sufficient presence of resident jaguars to prey on livestock repeatedly.

However, any corridors that become ‘successful’ in terms of being used by jaguars more regularly in future, run a high risk of becoming conflict hotspots, because they are likely to contain predisposing factors for conflict: presence of livestock and people at low-to-medium densities. Planning for possible emergence of conflict within in corridors may be key to their success in future, just as one would anticipate, and plan to manage for, conflict in areas into which carnivores have been reintroduced.

After showing several iterations of our risk map to jaguar experts from eight range states we found that most of the modelled risk areas were correct, with a few exceptions in places such as north of Copo National Park in Chaco province, Argentina. This area appears as a hotspot because it is a JCU and has a certain combination of cattle and human densities;

indeed Altrichter *et. al.* (2006) noted their surprise at finding almost no human-jaguar conflict here, despite the overlap of jaguars and livestock, and attributed this to the very low abundance of jaguars in the region. Conversely, they suggest that a lack of predation in a known jaguar range area, predicts or confirms low abundance of felids. Soto-Shoender & Giuliano (2011) also reported from their work in Guatemala that likelihood of conflict is simply a function of overlapping livestock and carnivore ranges, and we also observed in a study of jaguar conflicts in parts of the Mata Atlântica of Brazil (Chapter 4; de Barros *pers comm*), where jaguar numbers are very low, that conflict was negligible and of minor concern to communities. It is therefore likely that, due to the lack of range-wide jaguar abundance data, our model overestimates conflict hotspots in some places, although we tried to correct for this to some degree by excluding protected areas from the model.

The extent to which jaguars range outside of protected areas is of concern. Wittmyer *et al.* (2008) showed that human population growth on the edges of protected areas is higher than in other rural areas, particularly in Latin America. Woodroffe & Ginsberg (1998) explained that protected areas can represent population sinks by becoming hotspots where conflict with people is the main cause of mortality. Indeed, edge effects may be more consequential than overall population size of the species – i.e. good populations distributed across many small reserves leave large carnivores more at risk than if they exist in smaller populations spread across fewer large reserves (Woodroffe & Ginsberg, 1998; Woodroffe, 2001). Protected area edges can become ecological traps or attractive sinks - risky habitats that are attractive for species because of their short-term benefits (such as easy domestic prey) but are unsafe or otherwise not optimal for long-term survival (Delibes *et al.*, 2001; Kristan, 2003). A similar observation has been made for tigers in the Terai Arc, where a notable percentage of habitat outside protected areas was found to form attractive sinks (Kanagaraj *et al.*, 2011), warning that although tiger conservation must focus on the protection of core source areas (Walston *et al.*, 2010), such sinks can prove detrimental at

regional scales. For jaguars, conflict with people is much more pervasive than for tigers, and conservation strategies for the species needs to focus on mitigating mortality at these sinks, reducing their attractiveness and thereby managing the behavioural decisions of the species (Falcucci et al., 2009).

Most of the jaguar range is outside of protected areas, in livestock-raising regions with widespread risk of conflict with people. Our model at this range-wide scale is determined by the geographic concurrence of jaguars, cattle and people and cannot incorporate the finer details of localized conflict patterns. As such it is intended foremost for visualizing macro-spatial patterns for informing landscape-level conservation planning and priority-setting. There appear to be distinct hotspots of such conflict, and these may act as ecological traps for the species that may accelerate the decline of local populations. For the conservation of jaguars, strategic planning at the range-wide scale will need to focus on protecting core source populations, such as the best-protected Jaguar Conservation Units, while mitigating conflicts at its edges and adjacent risk hotspots, and planning for emerging conflicts in connected sections of the Jaguar Corridor.

Acknowledgments

We are grateful for the very helpful advice on our methodology and feedback on our results contributed by: Michelle Lee, Jorgelina Marino, Claudio Sillero, Susan Canney, Kathy Zeller, Lianne Petracca, Alan de Barros, Jose Soto, Esteban Payan, Ronit Amit and Rebecca Foster, as well as the *Wildlife Conservation Society* and *Panthera* for sharing spatial datasets created by their labs. This project was a collaboration of the Wildlife Conservation Research Unit of Oxford University and the Conservation Division of Chester Zoo, and was funded by Chester Zoo.

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Understanding human-jaguar conflict: lessons from case studies across the species' range

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Understanding human-jaguar conflict: lessons from case studies across the species' range

Abstract

Throughout their range, jaguars (*Panthera onca*) are persecuted for killing livestock, which is a wide-spread and serious threat to the species' survival. We conducted seventeen case studies in seven countries in order to identify any patterns which might allow us to improve the challenge of managing human-jaguar conflict across the range. Our study illustrates a very large variety of geographic, agronomic and socio-economic contexts, within heterogeneous communities, different farm types, varying extents of losses to jaguars, economic dependency on livestock and education levels. Both within and across the case studies there were considerable differences in farmers' experiences with livestock losses, concerns about depredation, levels of tolerance and attitudes, as well as social norms towards jaguars in each community. However, none of the situational factors alone could be used to predict how farmers perceive jaguars and deal with depredation. While patterns did exist within individual case studies, none were consistent across all, except for one: tolerance of, and attitudes towards, jaguars were most likely to be predicted to some extent by a factor of how many livestock a farmer loses to jaguars, combined with how he perceives the social norms of his community. We conclude that observations of patterns in human-wildlife conflict scenarios are valid only for informing action at a local scale, not for generalisation. In most cases, combined strategies focussing on reducing mortalities of livestock combined with social marketing to influence farmers' behaviours may be the broad way forward. Although each case is likely to require individual treatment, insights from wide-ranging studies can provide familiarity with the range of possible scenarios, adding breadth of information to depth of local knowledge.

Introduction

Throughout their range, jaguars (*Panthera onca*) are blamed and persecuted for attacks on livestock. Whether on large cattle ranches in the Mexican Sonora, the Brazilian Pantanal or the Venezuelan Llanos, at forest protected area edges in Guatemala and Belize, in the shrubby Cerrado of central Brazil, or the Amazon deforestation frontier, somewhere in each of its 19 range states, human-jaguar conflict threatens both people's livelihoods and the survival of the species.

The jaguar is the third-largest cat and survives alongside the smaller puma (*Puma concolor*) in all its range except El Salvador, Uruguay and Chile (Rabinowitz, 1997; Sanderson et al., 2002; McCain & Childs, 2008). The persecution of jaguars in retaliation for livestock depredation, as well as the hunting of their prey is the most serious threats to the survival of the species (Zeller, 2007) which is listed by the IUCN as *Near Threatened* (Caso et al., 2008). Human-jaguar conflicts are widespread and have been documented in all range states (e.g.: (Rabinowitz, 1986; Crawshaw & Quigley, 1991; Dalponte, 2002; Saenz & Carrillo, 2002; Schiaffino et al., 2002; Conforti & de Azevedo, 2003; Polisar et al., 2003; Scognamillo et al., 2003; Michalski et al., 2006; Azevedo & Murray, 2007a; Palmeira et al., 2008).

Through a survey of 117 experts across the range and a systematic review of 43 empirical studies (Chapter 2), as well as a spatial modelling exercise in which we combined conflict-relevant geospatial datasets with expert information (Chapter 3), we defined general range-wide patterns of human-jaguar conflict. Depletion of wild prey and poor livestock husbandry are reported as the key reasons for depredation, regardless of ecological, cultural or socio-economic context. Although losses of livestock are often not detrimental to livelihoods, fear and low tolerance of jaguars prevail throughout their range, and lead to

targeted or opportunistic killing of the cats (Chapter 2). In our predictive model of conflict hotspots (Chapter 3), we found that 85% of the total jaguar range, 72% of the total Jaguar Conservation Units (JCU) area and 90% of the Jaguar Corridor total area overlaps with livestock to some degree. Regions in which jaguars are repeatedly persecuted in retaliation for livestock depredation can be likened to ecological traps (unsafe areas with attractive prey, creating a population sink) (Delibes et al., 2001) and may lead to the decline of local populations (Chapter 3).

Range-wide studies are useful for understanding general patterns, informing policy and strategy, and the prioritization of landscape-level concepts such as the Jaguar Corridor Initiative (Rabinowitz & Zeller, 2010). However, this leaves the challenge of successful implementation of conflict mitigation on the ground. How do we translate ‘big picture’ general knowledge into conservation action on the ground, case by case? And conversely, how do we extrapolate case-specific experience to other locations?

Authors writing about human-wildlife conflict research often argue that each case of conflict is unique and therefore requires a customized solution (Woodroffe et al., 2005b; Dickman, 2010). Yet while such case-by-case conflict resolution may be ideal, there are simply not enough resources to implement customized action for each scenario. In short, we need some level of transferability of experience, processes and solutions. A thorough understanding of human-wildlife conflict requires both “micro and macro levels of analysis” at which we can learn about the effects of individual and cultural variation while also determining whether “techniques found successful in one area are likely to work in another” (Manfredo & Drayer, 2004).

In order to attempt to bridge the gap between range-wide observations and case-specific insights, we studied a series of case studies of human-jaguar conflict across nearly half the

species' range states, systematically collecting information to allow quantitative comparative analysis. We focus our analysis specifically on two objectives: 1) to describe a variety of human-jaguar conflict scenarios from across the jaguar range, searching for similarities and differences; and 2) to explore, in particular, patterns in levels of tolerance of depredation and attitudes towards jaguars, and the extent to which any such patterns may be consistent across the range.

Methods

The Case Study Approach

Case study, as a method for investigating phenomena in real-life contexts (Schwandt, 2007), is particularly useful for studying issues in which people's behaviour may vary according to a given situation (Flyvbjerg, 2011). However, single cases are not necessarily representative of a given population, and so we cannot generalise from these (Garson, 2002). In order to carry out statistical analyses and search for patterns, causes and explanations, one needs to examine and compare a sample of case studies (Druckman, 2005) and to combine context-specific insight with replicability and predictive power (Yin, 1989; Druckman, 2005; Schwandt, 2007; Flyvbjerg, 2011).

Aggregate or comparative case study, in which one systematically assembles information from a wide variety of scenarios serves to identify broad patterns (Yin & Heald, 1975; Firestone, 1993). Here the aim is not to understand in depth the causes of any specific conflict in each case, but to identify patterns in the type and possible causes of conflict across the sample of cases. This limits how much we can infer about cause-and-effect, but it allows for quantitative exploration of associations and trends (Firestone, 1993).

Case Selection

The range of the jaguar currently extends from southern Arizona to northern Argentina, and spans 19 range states (Sanderson et al., 2002). In a range-wide questionnaire survey, 86 experts described to us 117 cases of human-jaguar conflict in 17 of the range states (see Chapter 2). We then approached several of these experts about collaborating with more in-depth field case studies at various locations. The final selection of case studies was determined by feasibility, taking into account logistical factors such as access and availability of local field assistants to conduct the interviews. Such non-random, opportunistic sampling is appropriate here because case studies need not necessarily be representative – indeed for testing theories, atypical or outlier cases are useful, as they test the limitations of a hypotheses (Flyvbjerg, 2011). For the purpose of this research, the unit of a “case” was that of a community which keeps livestock in areas where there are jaguars, and where depredation is known to occur.

Sampling & Data Collection

Our purpose was to survey farmers with livestock who experience some level of depredation from jaguars – i.e. a stratified sample of the general population. Respondents could not be selected randomly because we did not have complete lists of all the farmers or observers in each given case study site. We used quota sampling (De Vaus, 2007) and interviewed on every farm that met the criteria of having experienced depredation, until a target of at least 20 interviews had been completed. In cases where the sampling population was large (many farms densely distributed) we used systematic sampling and selected every other farm for interview, and in cases where the sampling population was small (few or very large farms far apart), every farm was selected until the target was reached. The survey interviews were administered in the field by either research collaborators or local graduate students with experience in jaguar research and familiarity with the study sites. Having several local research assistants collect the data, rather than

one traveling to all sites, reduced micro-cultural biases (ie the interviewer was familiar with local norms and language variations) but carried potential for inconsistencies in data recording. This was considered preferable over the bias incurred if one data collector travelled to all sites and influenced interviewees by being perceived as a foreigner.

Survey Design

The questionnaire survey was designed in English with careful consideration to the research objectives, question structure and wording, consulting guidance literature and building on our own experience with questionnaire-based research (e.g. Zimmermann et al., 2005; Chartier et al., 2011; Davies et al., 2011; Wilson et al., 2013). The questionnaire underwent several drafts, peer review, pilot testing and revisions. It was then translated into Portuguese and Spanish by native speakers with subject knowledge, and the Spanish edited very slightly into several sub-versions to allow for linguistic variations in some countries.

The survey included questions about the respondent's background, information about the farm and livestock management, quantification of losses of livestock, perceptions about such losses, opinions about, and reactions to, jaguars, and options for mitigation. We used a mixed format of open and closed questions as well as Likert scales. Survey administration was structured and by interview, with a data collection protocol provided to the interviewer. Likert statements used three-point scales to assess attitudes, because some respondents find five-point scales confusing, and the distinction between "strongly agree" and "agree" then becomes meaningless.

The questionnaire was designed so that the answers to related groups of the 54 questions (the bulk of which form the focus of this chapter) could be combined into indices to measure aspects of particular interest to this study. The responses to the individual

questions could be scored and summed to give us the following indices (See Appendix 2 for full question wordings):

Economic dependence = dependence on livestock for income (Q33) + lack of other income sources (Q34) + lack of possibilities for alternative incomes (Q35)

Depredation concern = time spent dealing with the issue (Q15) + history of depredation (Q16) + worry about depredation (Q17)

Tolerance of jaguars = opinion that jaguars and people can co-exist (Q21) + willingness to make changes to husbandry (Q22) + considering depredation as a fact of life (Q24)

Attitudes towards jaguars = words to describe jaguar (Q25) + preferred outcome for jaguar species (Q32) + willingness to tolerate losses if it prevents jaguar extinction (Q36)

Social Norms = what happens when jaguar appears on someone's land (Q28) + neighbours' expectations (Q29) + whether people kill jaguars here (Q30).

Data Analysis

The survey data in three languages were entered in Excel (Microsoft Excel, v. 2010) and coded into numerical categories for statistical analysis. Descriptive analyses were done in SPSS (PASW Statistics, v.21, 2012), multivariate analyses in SAS (v. 9.3, 2011, SAS Institute Inc., Cary, NC, USA). The GIS maps were made in ArcView (v. 10.1, ESRI Inc., Redlands, CA). We first used a data reduction technique to summarise patterns in predictor variables. We applied a Principal Components Analysis (PCA) to summarise patterns in the type of farm, the reported losses to jaguars, and social norms concerning jaguars. The factor scores were then used as predictors in GLM models with jaguar attitude and tolerance as the responses. The models used the identity of the case studies as a categorical predictor to allow for among case variability in the response. The interaction terms involving case study were also included to test the hypothesis that the effect of predictors on the response varied among case studies (a 'significant' result for the interaction term indicating evidence for variation in the patterns between case studies).

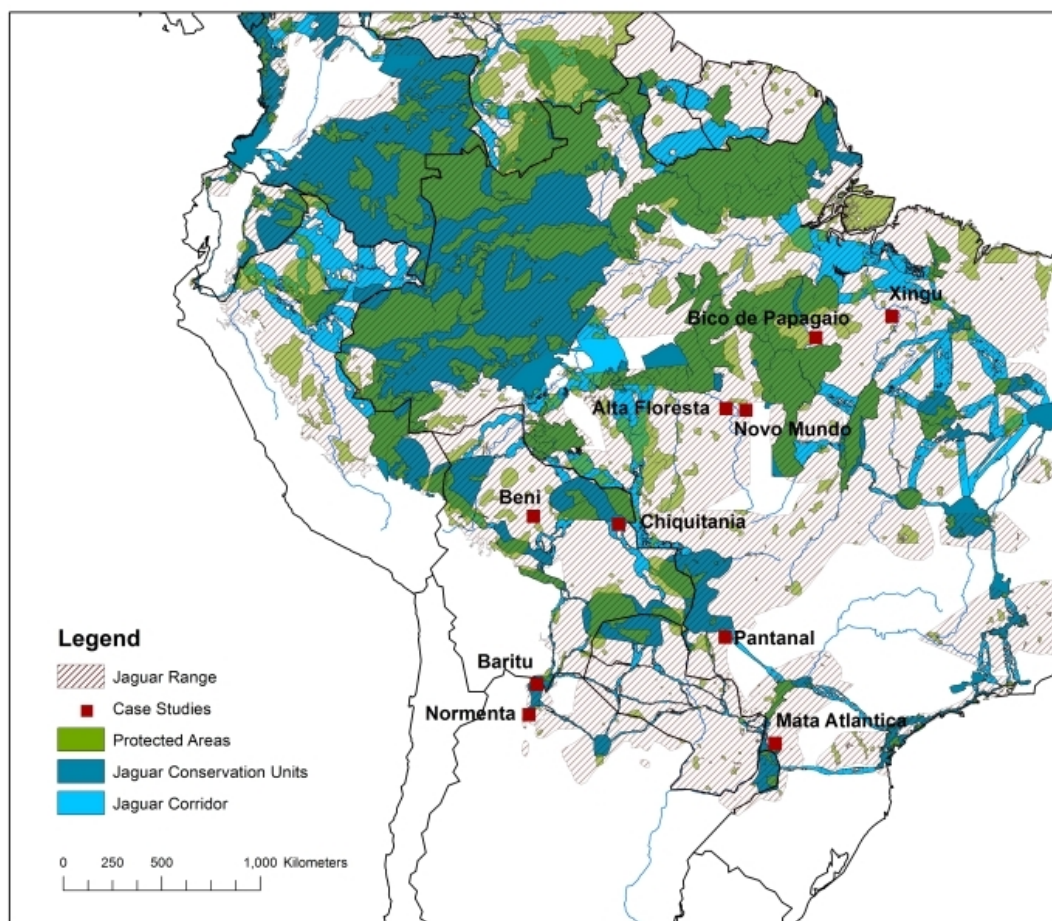
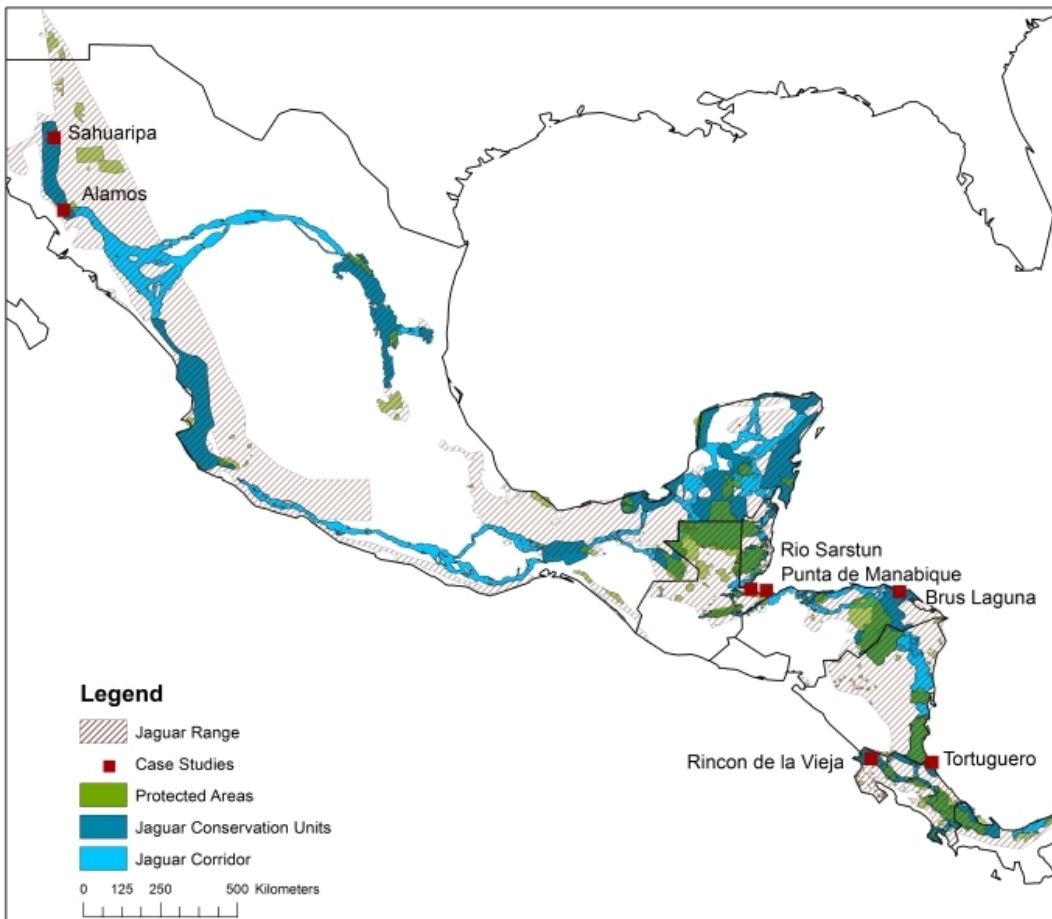
The Case Studies

Survey data collection took place between August 2011 and February 2012, in seven countries: Mexico, Guatemala, Honduras, Costa Rica, Brazil, Bolivia and Argentina (**Maps 1a & 1b**). For each case study, between 20 and 32 interviews were conducted (mean 24, total 409), with an average response rate of 87%. The 17 case studies were:

1. **Álamos (Sonora, México):** The municipality of Álamos is in the southeastern part of the Mexican state of Sonora. The 21 farms surveyed were on the edge of the Sierra de Álamos Rio Cuchujaqui Biosphere Reserve, inside the Sonoran JCU, characterized by tropical deciduous forest.
2. **Sahuaripa (Sonora, México):** Around 300km north of Álamos we surveyed 30 farms in the municipality of Sahuaripa. These were in the semi-arid scrublands at the edge of the Northern Jaguar Reserve, within the same JCU.
3. **Río Sarstún (Izabal, Guatemala):** This community between the River Sarstun and the municipality of Livingston, in lowland tropical forest and mangrove on the Caribbean coast, lies on the edges of a protected area (Área de Uso Múltiple Río Sarstún). This is outside of a JCU but very close (7km) to the Jaguar corridor below Cockscomb in Belize.
4. **Punta de Manabique (Izabal, Guatemala):** A small peninsula on the Caribbean coast, Punta de Manabique is a wildlife reserve of lowland tropical and mangrove forests. The community surveyed was between the Motagua River and the Refugio de Vida Silvestre Punta de Manabique. This is not within a JCU, and about 25km from the nearest section of Jaguar corridor connecting Guatemala and Honduras.
5. **Brus Laguna (Gracias a Dios, Honduras):** The municipality of Brus Laguna on the swampy Miskito Coast (La Mosquitia) of eastern Honduras is characterized by lowland forest and seasonally flooded grassland. The farms surveyed are inside the JCU of La Mosquitia and the nearest protected area surveyed is the Rio Plátano Biosphere Reserve, around 30-70km from the 20 farms surveyed.

6. **Tortuguero (Costa Rica):** The inland edges of Tortuguero National Park in Guácimo (Limón province) are characterized by grassland, plantations and pastures. We surveyed 20 farms within 10km of the protected area edge, inside the JCU of Talamanca.
7. **Rincón de la Vieja (Guanacaste, Costa Rica):** Rincón de la Vieja is the name of a volcano and region in NW Costa Rica, about 25 km from Liberia in the province of Guanacaste. The 28 farms surveyed were in the transition zone of dry forest to rain forest, in the Sector San Cristobal of the Guanacaste Conservation Area, which is inside the JCU of Guanacaste.
8. **Chiquitania (Santa Cruz, Bolivia):** the Chiquitania is a region of tropical savannas in the Santa Cruz department in eastern Bolivia. We surveyed 22 farms in the dry forest/scrub landscape at various distances southwest of Noel Kempff Mercado National Park, which is inside the JCU of Noel Kempff Mercado NP.
9. **Beni (Bolivia):** The Beni savannah (also called Llanos de Moxos) of northern Bolivia is a seasonally flooded plain similar to the Pantanal. We surveyed 23 farms in the Trinidad and Santa Ana municipalities of the state of Beni. The nearest protected areas are Estación Biológica del Beni, Reserva Regional Yacuna, Parque Nacional Isibaro Secure, which are between 30-100km from the farms surveyed. The area is neither in a JCU nor within a jaguar corridor.
10. **Normenta (Jujuy, Argentina):** In the Municipio Fraile Pintado, Yungas forest. The 23 farms surveyed were 11-30km from Calilegua National Park, inside the JCU of Baritu-Calilegua.
11. **Baritú (Salta, Argentina):** We surveyed 32 farmers in the municipalities of Los Toldos and Santa Victoria, around the edge of Baritú National Park in Salta Province, approximately 150km north of the Normenta case study. This is a region of cloud forest inside the same JCU.

12. **Mata Atlântica (São Paulo, Brazil):** In the Mata Atlântica (Atlantic Forest) of São Paulo state we surveyed 20 farms in the vicinities of three protected areas: Intervales State Park, Alto Ribeira State and Tourist Park (known as PETAR), and Carlos Botelho State Park. This is in lowland tropical forest and inside the JCU of the Atlantic Forest.
13. **Alta Floresta (Mato Grosso, Brazil):** The municipality of Alta Floresta in northern Mato Grosso state is an area of lowland tropical forest, which is neither in a JCU nor in a jaguar corridor, about 70-100km from Cristalino State Park. 28 farms were surveyed.
14. **Novo Mundo (Mato Grosso, Brazil):** The municipality of Novo Mundo is approximately 100km west of Alta Floresta in the northern part of Mato Grosso state. We surveyed 22 farms within 10km of Cristalino State Park. This is not in a JCU nor in a corridor.
15. **Pantanal (Mato Grosso do Sul, Brazil):** Our case study was carried out in the southern part of this well-studied, world's largest wetland, in the districts of Miranda and Corumba. This seasonally flooded grassland with forest islands and riparian forests is almost entirely privately owned by many large cattle ranches. There are scatterings of RPPNs (Reserva Particular do Patrimonio Natural). The entire area is a JCU.
16. **Bico de Papagaio (Tocantins, Brazil):** The Bico do Papagaio region is transitional region between the Cerrado and the Amazonian forest biomes, at the northern tip of Tocantins state. We surveyed 25 farms in several municipalities. The region is neither a JCU nor a corridor, and there are some small reserves and indigenous territories and the Parque Estadual da Serra dos Martírios/Andorinhas.
17. **Xingú (Pará, Brazil):** Also in the ecotone between Cerrado and Amazonian forest biomes, the municipalities of São Félix do Xingu, Tucumã and Ourilândia were the site for our 22 farms surveyed. The region has various protected areas and indigenous territories, including the Parque Nacional da Serra do Pardo. This area is neither a JCU nor a corridor.



Maps 1a & 1b: Locations of the case studies.

Results

Characteristics of case studies and farms

Farm sizes and types:

In Punta de Manabique, Rincón de la Vieja and Tortuguero, farms were mostly small (<100ha) with small herds of livestock (<100 head). In Álamos, Río Sarstún, Brus Laguna and Novo Mundo the majority of farms surveyed were also fairly small (<500ha) but there was a larger range of property sizes, up to around 5000ha. Livestock herd sizes were mostly <100 in Río Sarstún and Álamos, and <500 in Brus Laguna and Novo Mundo. In Baritú we have no property sizes because the land was considered communal, and nearly all had <100 head of cattle.

In Sahuaripa, Normenta, Chiquitania, Alta Floresta, Mata Atlântica and Bico de Papagaio there was a large range of property sizes with a proportion of farms up to several thousand hectares large, and livestock holdings of up to 1,000. The Beni, the Pantanal, Xingú had the largest farms. Xingú and Beni had similar mean property sizes (3,773ha and 3,997ha respectively) but a range of sizes existed in both, from around 100 to >40,000ha. The Pantanal had the largest ranches; 60% were over 5,000ha (one was 80,000ha) and 75% of the farms had >1,000 head of cattle (up to 40,000 head), see **Table 1 & Figure 1**.

Case Study	N	Property size (hectares)				Number of livestock				Husbandry type
		Min	Max	Mean	StDev	Min	Max	Mean	StDev	
Álamos (Mexico)	21	43	1,500	378	401	11	384	90	86	intensive (57%)
Alta Floresta (Brazil)	28	32	20,000	1,460	3,851	68	12,080	1,079	2,398	intensive (79%)
Baritú (Argentina)	31	n/a	n/a	n/a	n/a	9	103	32	19	extensive (87%)
Beni (Bolivia)	23	130	30,000	3,773	6,402	209	8,120	1,502	2,107	extensive (100%)
Bico de Papagaio (Brazil)	25	25	15,600	1,863	4,136	16	6,310	918	1,434	extensive (72%)
Brus Laguna (Honduras)	20	2	5,370	687	1,559	9	1,800	203	395	extensive (90%)
Chiquitania (Bolivia)	22	50	5,000	1,127	1,662	28	3,015	696	835	very mixed
Mata Atlantica (Brazil)	20	25	12,100	1,520	3,007	12	2,520	364	686	very mixed
Normenta (Argentina)	23	40	2,000	602	512	13	113	50	28	mixed (ext 48%)
Novo Mundo (Brazil)	22	3	2,400	322	619	2	712	189	222	mixed (int 52%)
Pantanal (Brazil)	32	600	80,000	13,776	18,127	30	41,400	5,447	9,462	extensive (97%)
P. de Manabique (Guatemala)	21	11	135	48	35	-	390	65	84	very mixed
Rincón de la Vieja (Costa Rica)	28	1	310	51	79	-	410	71	100	mixed (int 55%)
Río Sarstún (Guatemala)	21	23	1,710	594	626	-	500	54	112	subsistence (57%)
Sahuaripa (Mexico)	30	3	8,000	1,451	1,656	24	520	88	95	very mixed
Tortuguero (Costa Rica)	20	4	600	126	163	17	380	100	112	extensive (65%)
Xingú (Brazil)	22	55	43,000	3,997	9,179	59	86,486	5,166	18,257	extensive (96%)

Table 1: Ranges and means of property sizes and livestock herds of each case study.

We categorized the surveyed farms into three types: smallholdings, mixed farms, and cattle ranches by scoring the variables *property size*, *land used for cattle*, *husbandry type*, and *number of livestock*. One case study, Tortuguero, consisted of only mixed farming. Five case studies (Rio Sarstun, Brus Laguna, Chiquitania, Normenta and Bico de Papagaio) contain all three farming types. The Pantanal and the Beni were almost identical, containing mostly (87-88%) cattle ranches. Even the three pairs of geographically clustered case studies, i.e. Sonora (Alamos & Sahuaripa), Guatemala (Rio Sarstun & Manabique) and Mato Grosso (Alta Floresta & Novo Mundo) were very different from each other in terms of farm type composition (**Figure 2**).

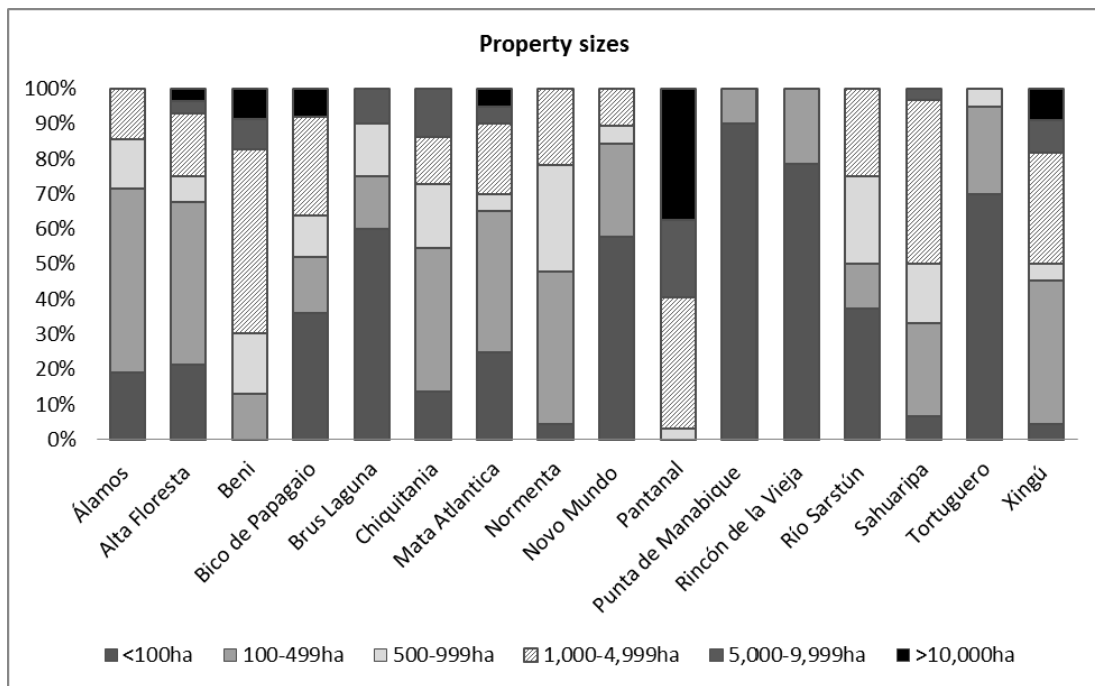


Figure 1: Farm size brackets within each case study

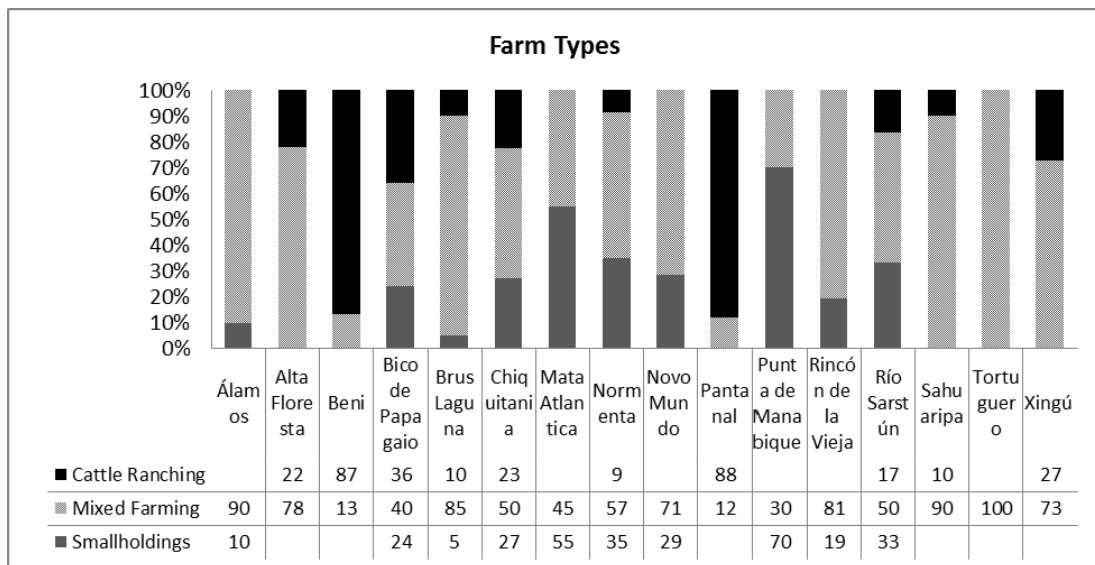


Figure 2: Composition of farm types observed in each case study (excluding Baritu, where property sizes were not known)

Impacts of jaguar depredation

Extent of losses:

Respondents were asked how many livestock (cows, equids, buffaloes, pigs, goats or sheep) they have, and the minimum and maximum number of stock they lose per year to jaguar predation. We used the maximum losses figure to calculate a maximum percentage of stock lost to jaguar. In Alta Floresta and Novo Mundo (both in Mato Grosso, Brazil), as well as in the Beni, respondents reported the lowest proportions of losses (maxima $\leq 5\%$), while in Baritú, Brus Laguna, Mata Atlântica and Rio Sarstún, 42-55% of farmers claimed that they lose a maximum of $>10\%$ of their stock to jaguars annually.

Pumas were also considered a problem to some extent in all case studies except in Tortuguero and in Rincon de la Vieja, where they were deemed a problem by only 4% of respondents. Farmers were asked about the *history of jaguar depredation*, and whether the *time they spend dealing with depredation* has increased, decreased or stayed the same in recent years. In the two large cattle ranching regions – Beni and Pantanal – most reported a long history of problems with jaguars, while in Bico de Papagaio, Mata Atlântica and Normenta, a proportion said it was a new problem. The extent to which farmers consider it to be a “serious or very worrying” issue also varied across the range, with Rincon de la Vieja and Sahuaripa having the highest proportions of worried respondents (see **Table 2**).

We asked respondents about their main challenges for their farms and livelihoods. **Table 2** summarises the most-cited concerns in each case study. In around half (9) of the case studies, problems with livestock (health, production) was mentioned as the main challenge, and in around a third (6) case studies, climatic conditions (drought and floods) were the most-cited problems.

Case Study	Percentage of farmers with losses to Jaguars as % of total livestock				Pumas a problem? % yes	History of depredation		How serious are livestock losses		Main challenges for the farm (most frequently cited)
	<1%	1-5%	5.1-10%	>10%		% many years	% not	% very	% not	
Álamos (Mexico)	48	24	19	10	45	-	29	30	10	Drought
Alta Floresta (Brazil)	74	26	-	-	50	29	4	43	29	cost of equipment/supplies
Baritú (Argentina)	10	7	36	48	94	23	10	10	3	Land productivity, tenure
Beni (Bolivia)	26	74	-	-	83	83	-	-	4	Livestock mortalities, reproduction, productivity
Bico de Papagaio (Brazil)	36	28	16	20	40	56	-	8	44	Financial difficulties, poor soil, technical support, weather extremes
Brus Laguna (Honduras)	5	10	30	55	55	70	-	45	5	Livestock health, husbandry and productivity
Chiquitania (Bolivia)	64	18	18	-	19	41	-	32	9	Drought, livestock health, production
Mata Atlantica (Brazil)	20	20	10	50	50	25	5	35	35	Access to markets, livestock and crop yields, infrastructure, snakes
Normenta (Argentina)	9	26	48	17	74	30	-	31	-	Improving cattle husbandry, land security issues.
Novo Mundo (Brazil)	67	33	-	-	33	23	18	36	5	Pests, government support, infrastructure.
Pantanal (Brazil)	44	47	9	-	91	94	-	25	9	Infrastructure, transport costs, weather extremes, productivity.
Punta Manabique (Guatemala)	14	29	36	21	24	33	5	35	20	Flooding, loss of crops, disease, fishing yields, land tenure
Rincón de la Vieja (Costa Rica)	29	42	13	17	4	11	32	50	21	Sale of stock, markets, income, livestock production
Río Sarstún (Guatemala)	25	8	25	42	10	10	-	45	-	Cost of fuel, poor fishing yields, poor crops, land tenure, security
Sahuaripa (Mexico)	17	30	27	27	87	43	3	67	13	Drought
Tortuguero (Costa Rica)	21	47	16	16	-	45	-	30	15	Flooding
Xingú (Brazil)	46	41	14	-	59	64	-	32	18	Infrastructure, vaccines, land tenure, security, technical support

Table 2: Impacts of depredation

Economic Dependence:

The extent to which respondents depend on livestock was quantified by scoring a farmer's *reliance on livestock for income, whether he has any other income sources, and whether he has any future options for other livelihood sources*. An additive score of these responses gave us an index of economic dependence on livestock and a score between 0-8 (where 8 is the most dependent) (**Figure 4**). There was strong evidence that these scores differed between case studies ($F_{16,284} = 21.3, P < 0.001$). The two Guatemalan case studies, Rio Sarstún and Punta de Manabique, had the lowest mean economic dependence indices (1.76, SE=1.73 and 2.43, SE=1.83 respectively). The farmers of the Beni reported being most dependent on livestock for their income (7.22, SE=0.67), followed closely by Alta Floresta, Pantanal, Bico de Papagaio, Sahuaripa, Chiquitania and Xingú – which all had means >6.5.

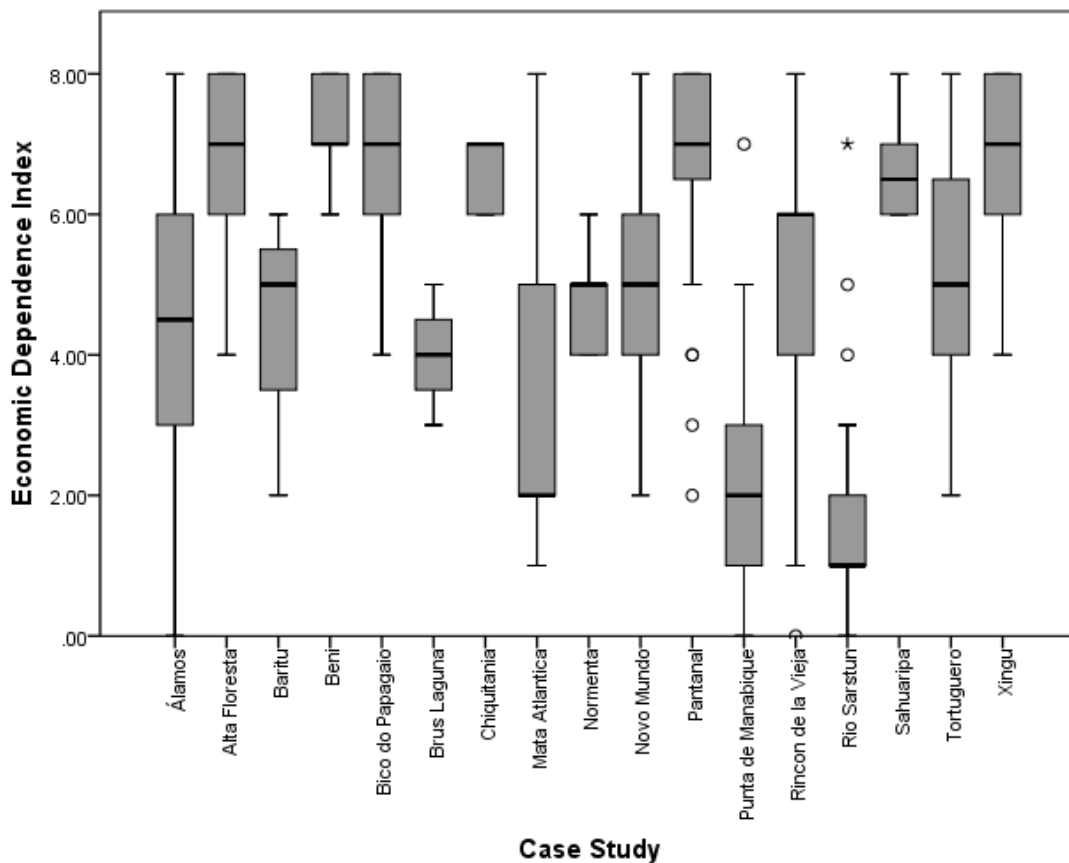


Figure 4: Economic dependence scores (0-8, where 8 is the most dependent) for each case study, showing ranges, medians and outliers for each case study.

The latter six case studies appear to have in common that they contain a proportion of ranch-type farms, however, so do three other case studies (Rio Sarstún, Brus Laguna, Normenta), for which the mean economic dependence is fairly low. Economic dependence varied significantly with farmer type ($F_{2,238} = 12.7, P < 0.001$), and with case study ($F_{15,238} = 17.8, P < 0.001$) and there was no evidence that this pattern varied with case study ($F_{15,238} = 1.45, P = 0.123$). The highest economic dependence tended to be on ranches (mean = 6.76, SE = 0.15), with lower values on mixed-type farms (mean = 5.71, SE = 0.16) and the lowest dependence scores on smallholdings (mean = 3.05, SE = 0.31).

Depredation Concern:

How worried or concerned a farmer was about losing livestock to jaguars could be measured by deriving an aggregate score for their responses to questions about *time spent dealing with the issue, history of depredation, and how worrying a threat it is*. **Figure 5** shows the scores for each case study: there was strong evidence the scores differed between case studies ($F_{15,310} = 6.73, P < 0.001$), the two cattle ranch-dominated case studies, Pantanal (mean 7.72, SE = 1.67) and Beni (mean 7.70, SE = 1.40) had among the highest levels of depredation concern, along with Brus Laguna, Chiquitania, Sahuaripa, and Tortuguero.

For this response, there was evidence that the effect of farm type varied among case studies (farm type*case study interaction term, $F_{15,310} = 2.44, P = 0.0011$). Overall, there was no trend in depredation concern with education levels ($F_{1,313} = 0.52, P < 0.470$), but there was some evidence that the effect differed between case studies (farm type*case study interaction term, $F_{14,310} = 1.71, P = 0.054$). In four case studies (Alta Floresta, Baritu, Normenta and Novo Mundo), lower education levels were correlated significantly with higher concern about depredation, although in Pantanal, the opposite was true, and the remainder of case studies showed no such relationship. There were a few other significant correlations in various case studies (see **Table 3**) but none were consistent across the

range, and in many cases the directions of these relationships were inconsistent (e.g. in Álamos those with large properties were more concerned, while in Alta Floresta the opposite was true).

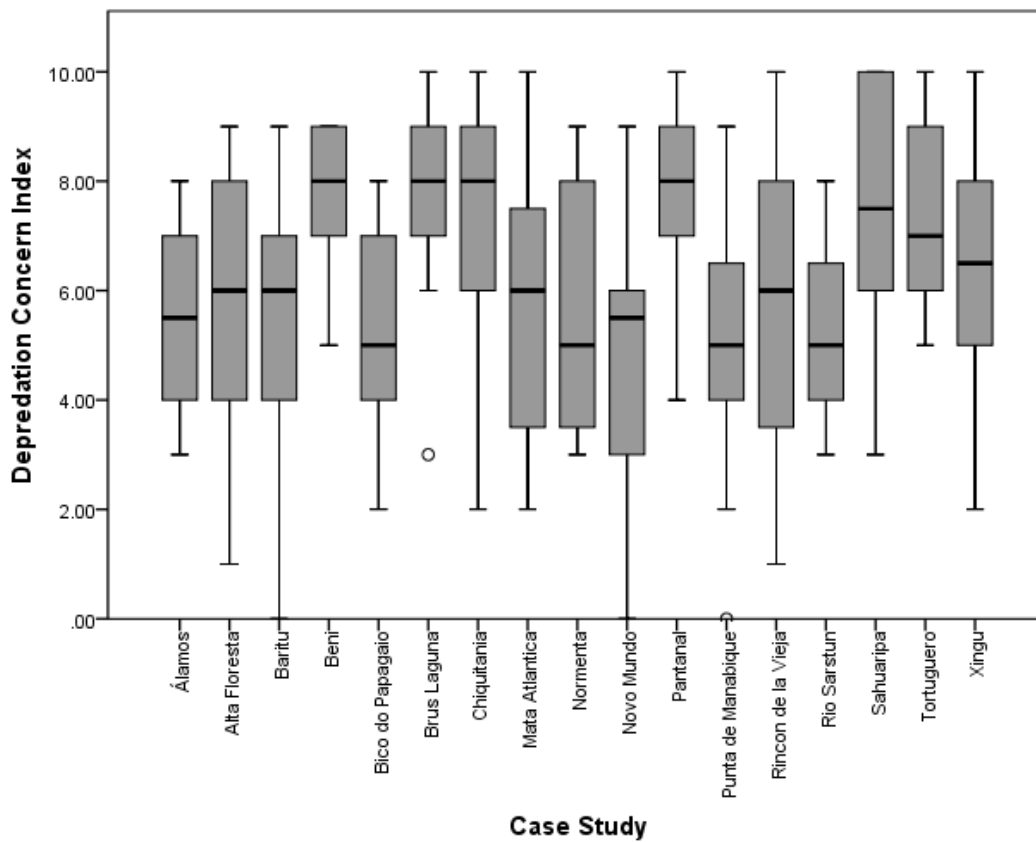


Figure 5: Indices of depredation concern for each case study, where 10 is most concerned about depredation of livestock

There was strong evidence that the effect of losses on depredation concern varied between case studies (type*case study interaction term, $F_{16,337} = 2.74$, $P=0.0004$). Inspection of individual case studies revealed that depredation concern was correlated significantly with actual losses of livestock in five of the case studies, in which those with a larger proportion of losses were most concerned about losing livestock: Baritu ($r=0.563$, $n=31$, $p<0.001$), Mata Atlantica ($r=0.608$, $n=20$, $p<0.01$) Normenta ($r=0.578$, $n=23$, $p<0.01$, Sahuaripa ($r=0.401$, $n=30$, $p<0.05$), and Tortuguero ($r=0.671$, $n=19$, $p<0.05$). Higher levels of concern were also significantly correlated with lower tolerance of depredation in seven case studies (Beni, Mata Atlântica, Normenta, Pantanal, Rincon, Sahuaripa dn Xingú), and with more

negative attitudes in five case studies (Mata Atlântica, Normenta, Pantanal, Sahuaripa and Xingú).

Variable	Variable	Case Study	r=	rho=	p	n	
Depredation Concern	Age	Álamos	-.561*		0.01	20	
		Normenta	.697**		0.00	23	
	Education	Alta Floresta			-.448*	0.02	28
		Baritu			-.400*	0.03	31
		Normenta			-.467*	0.02	23
		Novo Mundo			-.487*	0.02	22
		Pantanal			.534**	0.00	32
	Rootedness	Baritu	.403*			0.02	31
		Normenta	.432*			0.04	23
		Novo Mundo	.526*			0.01	22
	Property size	Álamos	.452*			0.05	20
		Alta Floresta	-.449*			0.02	28
		Normenta	.694**			0.00	23
	Number of livestock	Alta Floresta	-.427*			0.03	27
		Baritu	.389*			0.03	31
		Normenta	.770**			0.00	23
	Land used for livestock	Baritu	.621**			0.00	31
		Normenta	.723**			0.00	23
		Pantanal	-.408*			0.02	32
		Xingu	-.428*			0.05	22
	Livestock losses	Baritu	.563**			0.00	31
		Mata Atlantica	.608**			0.00	20
		Normenta	.578**			0.00	23
		Sahuaripa	.401*			0.03	30
		Tortuguero	.571*			0.01	19
	Economic dependence	Alta Floresta	.554**			0.01	21
		Mata Atlantica	-.466*			0.04	20
Xingu		.686**			0.00	22	
Tolerance	Alta Floresta	.580**			0.00	28	
	Beni	-.449*			0.03	23	
	Mata Atlantica	-.481*			0.03	20	
	Normenta	-.594**			0.00	23	
	Pantanal	-.572**			0.00	32	
	Rincon	-.400*			0.04	27	
	Sahuaripa	-.470**			0.01	30	
Xingu	-.451*			0.04	22		
Jaguar attitude	Mata Atlantica	-.503*			0.02	20	
	Normenta	-.619**			0.00	23	
	Pantanal	-.439*			0.01	31	
	Sahuaripa	-.404*			0.04	26	
	Xingu	-.607**			0.00	22	
Social norms	Álamos	-.546*			0.01	20	
	Pantanal	-.415*			0.02	30	

Table 3: Correlations with Depredation Concern: * significant at the 0.05 level, ** at the 0.01 level.

Tolerance, attitudes and norms

Tolerance of jaguars:

The extent to which farmers are willing to tolerate losses of livestock to jaguars was quantified by scoring their responses to the likert items: *it is possible for both people and jaguars to live in this area, I am willing to make changes to how I keep my livestock and losing some livestock to jaguars is a fact of life that I can accept*. There was strong evidence that these scores differed between case studies ($F_{16,391} = 5.9, P < 0.001$). Such measure of tolerance was highest in the Pantanal (7.16, SE=2.08), Bico de Papagaio (6.96, SE=2.05) and Alta Floresta (6.93, SE=2.37) – three cases which otherwise do not appear to have very much in common. In the Beni, which is similar to the Pantanal in terms of farm type composition, tolerance was among the lowest (4.09, SE=2.27) **Figure 6**.

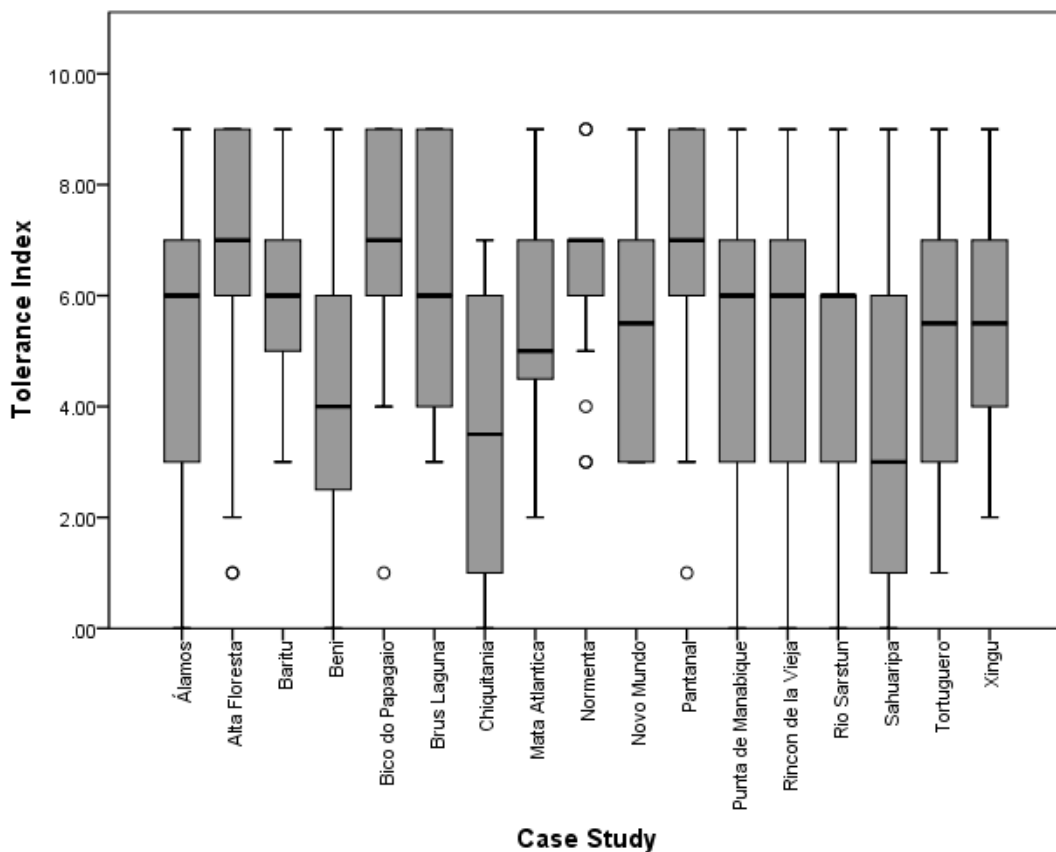


Figure 6: Depredation tolerance scores for each case study, where 9 is the most tolerant of jaguars.

Overall, higher tolerance of depredation increased significantly with more positive attitudes towards jaguars ($F_{1,392} = 69.9, P < 0.001$) and there was no evidence that the effect differed between case studies ($F_{16,392} = 1.29, P = 0.204$). The trends at Beni, Mata Atlântica, Rincon de la Vieja, Rio Sarstún, Sahuaripa, and Xingú were particularly clear (**Table 5**).

Attitudes towards Jaguars:

When asked *what outcome they would prefer for jaguars*, only in six cases studies did a small proportion of respondents (4-11%) wish them extinct (Álamos, Beni, Bico do Papagaio, Novo Mundo, Rio Sarstún and Sahuaripa). In the remaining case studies no respondents chose the “extinct” option. In all 17 case studies there was a proportion (between 21-71%) of respondents who said they would have the same number of jaguars as there are now, and in 13 case studies (all except Brus Laguna, Chiquitania and Novo Mundo) between 4-22% (mostly >14%) of respondents even said they would like it if there were more jaguars.

We also asked farmers *which three words they would use to describe jaguars*, and assigned scores – based on the view point of conservation values - to each of their words as either negative (e.g. “killer, dangerous”), neutral (e.g. “yellow, big”) or positive (e.g. “beautiful, important”). In the majority of cases the words were clear and straightforward to score, although some words such as “important” can arguably have different meanings. If in doubt, words were scored as neutral. They were also asked whether they *would be willing to tolerate any losses of their livestock to jaguars*, if this meant the species would not go extinct. In all case studies, a proportion (between 20-97%) of respondents replied yes (**Table 4**).

The responses to these three questions (about preferred outcome, three words, and tolerating losses) were scored into a jaguar attitude overall score between -6 and +6. The

case studies with the most positive mean jaguar attitude scores were the Pantanal (2.65, SE=2.30) and Alta Floresta (2.11, SE=1.95). The most negative mean scores were in Brus Laguna (-1.95, SE=2.52) and Chiquitania (-1.00, SE=1.97) (**Figure 7**).

Case study	Willing to tolerate losses of livestock	Preferred outcome for jaguars		Jaguars threaten my way of life	Do people kill jaguars here	Protecting jaguars is a waste of money
	"yes"	"extinct"	"more here"	"agree"	"yes"	"agree"
Álamos	52	10	19	29	33	33
Alta Floresta	79	-	7	18	82	14
Baritu	81	-	6	-	65	19
Beni	57	9	-	26	100	13
Bico do Papagaio	88	4	12	16	52	24
Brus Laguna	30	-	-	5	90	25
Chiquitania	73	-	-	27	95	32
Mata Atlantica	85	-	15	30	45	40
Normenta	78	-	4	4	91	4
Novo Mundo	43	5	-	27	77	41
Pantanal	97	-	22	31	91	25
Punta de Manabique	29	-	14	19	86	24
Rincon de la Vieja	46	-	14	43	7	29
Rio Sarstun	24	5	14	33	62	14
Sahuaripa	23	11	14	67	47	17
Tortuguero	25	-	20	20	25	11
Xingu	82	-	18	32	95	27

Table 4: Key responses to jaguar attitude questions (percentages of respondents per case study)

Adjusting for case study, attitudes towards jaguars did not differ across the three farmer types ($F_{2,303} = 0.30, P=0.744$), e.g. within case studies, ranchers were not more or less positive about jaguars than mixed farm owners or smallholders). There was no evidence that this differed between case studies ($F_{18,392} = 1.15, P=0.306$). Because the distribution of farmer types differed between case studies, the effect of farmer type was statistically significant if entered to the GLM model first ($F_{2,321} = 4.86, P=0.0083$), where attitudes were more positive for farm type 3 (smallholder) compared with farms type 1 or 2, (rancher, mixed) but this cannot be disentangled from the case-study effect. Indeed few variables were correlated with jaguar attitude, and in most cases only for one case study, which does not suggest any generalizable patterns. For example, in the Beni, those with more livestock were more positive about jaguars ($\rho=0.455, n=23, p<0.05$); in Xingú the less economically dependent respondents were more positive ($\rho=0.447, n=22, p>0.05$). However, these correlations were not significant in any other case studies (**Table 5**).

Variable	Variable	Case Study	r=	rho=	p	n
Tolerance	Age	Mata Atlantica	-.539*		.014	20
		Normenta	-.678**		.000	23
		Tortuguero	-.585**		.007	20
	Rootedness	Novo Mundo	.435*		.043	22
	Property size	Alta Floresta	-.496**		.007	28
		Beni	.505*		.014	23
		Normenta	-.779**		.000	23
	Number of livestock	Alta Floresta	-.685**		.000	27
		Beni	.425*		.043	23
	Land used for livestock	Brus Laguna	-.446*		.049	20
		Normenta	-.462*		.027	23
	Economic dependence	Alta Floresta	.616**		.003	21
		Beni	.665**		.001	23
	Jaguar attitude	Mata Atlântica	.629**		.003	20
		Rio Sartstun	.739**		.000	20
		Sahuaripa	.669**		.000	26
Xingú		.495*		.019	22	
Social norms	Pantanal	.480**		.007	30	
Jaguar Attitude	Age	Normenta	-.493*		.017	23
	Education	Beni		.492*	.017	23
		Normenta		.518*	.011	23
		Sahuaripa		.470*	.015	26
	Rootedness	Baritu	.390*		.030	31
		Normenta	-.506*		.014	23
	Property size	Beni	.504*		.014	23
		Tortuguero	.493*		.027	20
	Number of livestock	Beni	.469*		.024	23
		Tortuguero	.481*		.032	20
	Land used for livestock	Pantanal	.380*		.035	31
		Xingú	.436*		.043	22
	Livestock losses	Normenta	-.450*		.031	23
	Economic dependence	Xingú	-.449*		.036	22
	Social norms	Novo Mundo	.550*		.015	19
	Social Norms	Rootedness	Rincon	.449*		.017
Land used for livestock		Chiquitania	.436*		.043	22
Livestock losses		Alamos	-.438*		.047	21
		Beni	.496*		.019	22
		Normenta	-.571*		.026	15
Economic dependence		Normanta	-.798*		.018	8
		Pantanal	.375*		.041	30
Tolerance		Pantanal	.480**		.007	30

Table 5: Correlations with tolerance, attitude and norms: * significant at the 0.05 level, ** at the 0.01 level.

Social norms about reactions to jaguars:

Possible influences on farmers' attitudes through social norms (commonly-held beliefs about how people behave in a given context) were measured with the questions: *what happens when a jaguar appears on someone's land; what would your neighbours expect you to do if a jaguar came onto your land, and do people kill jaguars around here*. The responses were scored so that any mention of killing jaguars was given -2 points, and any "leave it alone" response would be scored +2, to give us an additive scale ranging from -6 to +6. Across the range, only the two Costa Rican case studies (Tortuguero and Rincon) had median social norm indices above zero. Everywhere else, the scores were negative, and clearly lowest in Beni (mean -5.27, SE=.46) and Xingú (mean -4.14, SE=1.88) followed by Brus Laguna, Normenta and Novo Mundo. There was, however, a great deal of variation among the responses. **Figure 7** shows the ranges of social norm measurements next to attitude scores for each case study. In many cases the two scales are not at all similar: e.g. in the Pantanal, ranchers' attitudes towards jaguars were among the most positive, but they reported community norms to be quite negative.

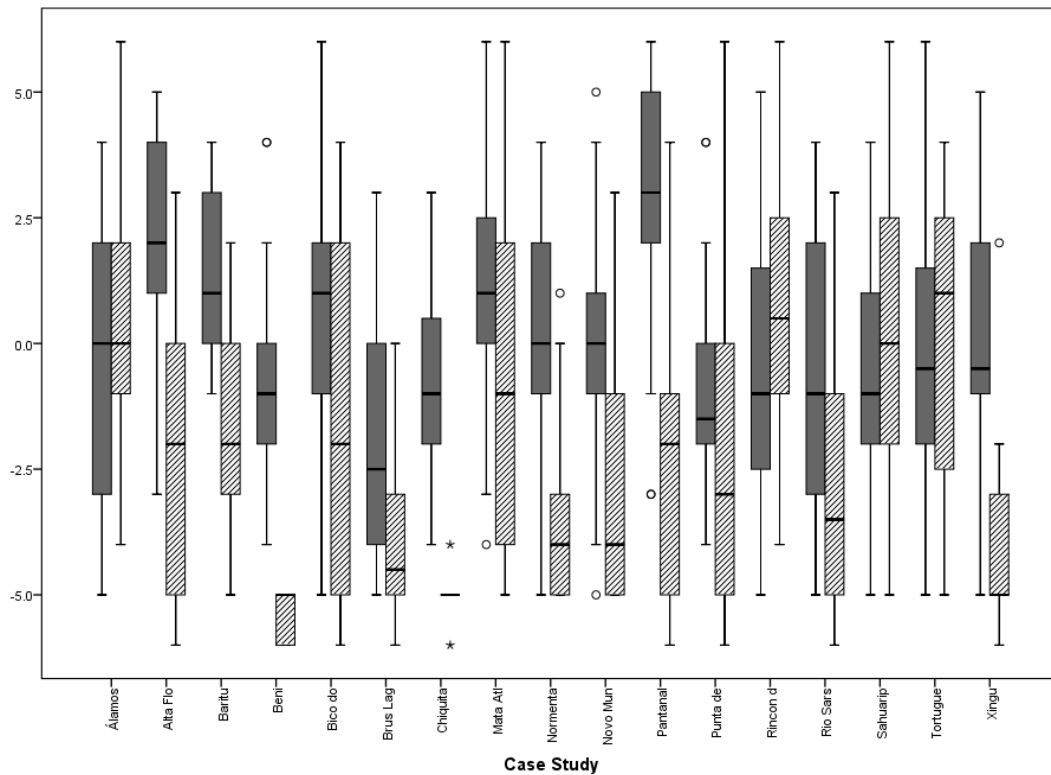


Figure 7: Range of scores for attitudes towards jaguars (solid grey boxes) and social norms about jaguars (striped boxes), where +6 is the most positive attitude or norm. (Circles are outliers and asterisks are extreme outliers).

There was strong evidence that social norm scores differed between case studies ($F_{16,365} = 12.88, P < 0.001$). There was also a general tendency for scores to be higher where attitudes were more positive ($F_{1,350} = 5.62, P = 0.018$) and no evidence that this trend differed among case studies (case study*attitude interaction, $F_{16,334} = 1.23, P = 0.242$). The relationship between social norms and tolerance was similar, there was weak evidence for a positive association: social norms were higher where tolerance was higher ($F_{1,63} = 3.84, P = 0.051$), and no evidence for that this was not general across case studies ($F_{16,347} = 1.06, P = 0.396$). Social norms were correlated significantly with attitudes only in Normenta ($r = 0.55, n = 19, p < 0.05$), and with tolerance levels in only the Pantanal ($r = 0.480, n = 23, p < 0.01$), see **Table 5**.

Predicting tolerance and attitudes

To summarise patterns of how socio-economic factors predict farmers' attitudes towards jaguars and their tolerance of losses to jaguars, and how this varies across the species' range, we analysed the case studies with a principal component analysis (PCA) and general linear model (GLM) using the PCA scores as predictors. (The case study Baritu was omitted as farm areas were not available).

The variables *property size (log transformed)*, *number of livestock (log transformed)*, *losses to jaguars*, *economic dependence on livestock*, *education level* and *social norms index* were input to the PCA. Inspection of the factor loadings for Factor 1 suggests that high scores on factor 1 are associated with large farms with large herds and high dependence economic dependence on livestock property size, number of livestock, and economic dependence (**Table 6**). High factor 2 scores are associated with high losses and low social norm scores and low social norm scores concerning retaliation against jaguars, so a high score on Factor 2 (x-axis) would be one that has high livestock losses and reportedly low positive social norms about jaguars.

Factor Pattern	Factor 1	Factor 2
Farm property size	0.85	0.06
Livestock herd size	0.90	-0.03
Losses to jaguars	-0.37	0.72
Education	0.60	0.50
Economic dependence	0.62	-0.41
Social norms	-0.45	-0.46

Table 6: Correlations between input variables and ordination scores. The eigenvalues for factors 1 and 2 were 43.6% and 19.4% respectively.

In the PCA plot (**Figure 9**), the top-right quadrant shows large farms with many livestock, high dependence on livestock, relatively many losses to jaguars, and overall negative social norms (i.e. jaguar killing is prevalent in the community). Samples from the Beni are noticeably clustered into this section, along with a number from Pantanal, Chiquitania and

Xingú – which also feature in the top-left, indicating large farms and lower losses with more positive norms.

The bottom-right quadrant (representing smaller farms, fewer livestock, lower dependence on livestock, but higher losses and more negative social norms), shows a clustering of samples from Brus Laguna, Normenta, Mata Atlântica and Punta de Manabique. The latter two also extend into the bottom-right quadrant (indicating smaller farms with fewer livestock, lower dependence, fewer losses, and more positive norms), which is otherwise dominated by samples from Tortuguero, Rincón de la Vieja, and Sahuaripa. The case studies of Novo Mundo, Alta Floresta, Bico de Papagaio and Alamos are fairly evenly distributed across the plot, suggesting a wide variety of situations.

Next we explored to what extent tolerance of jaguar depredation and attitude towards jaguars could be predicted by a given farmer's position on the above summary of their situation. As shown above, levels of tolerance and attitudes vary across the case studies (see **Figures 5 & 6**), and are also correlated with each other across the case studies ($r=0.46$, $n=393$, $p<.0001$) (only significantly so in 6 cases, but to a weaker extent all cases). A GLM analysis shows us some trends:

The PCA provided a useful summary of the input variables with 63% of the variability in inputs summarised on the first two axes. Factor 1 (summarising property size, number of livestock, and economic dependence) does *not* predict tolerance in a GLM model adjusting for case study and nor was there any evidence this conclusion varied between case studies (main effect: $F_{1,203} = 0.07$, $P=0.78$, interaction $F_{15,203} = 1.28$, $P=0.22$). Factor 2 (consisting of losses to jaguars and social norms) *does* predict tolerance, though the evidence was not strong ($F_{1,229} = 3.84$, $P=0.065$) and was weaker if the two outliers on factor 2 were omitted ($P=0.15$). When we repeated the same analysis for attitudes, conclusions were similar the

factor scores were not useful predictors of attitudes to or tolerance of jaguars if the identity of the case study is adjusted for. In other words, consistently across all our 17 very varied case studies, a farmer's tolerance of, and/or attitude towards jaguars cannot be predicted by variation in how much land and livestock he has, nor how dependent he is on this for his livelihood.

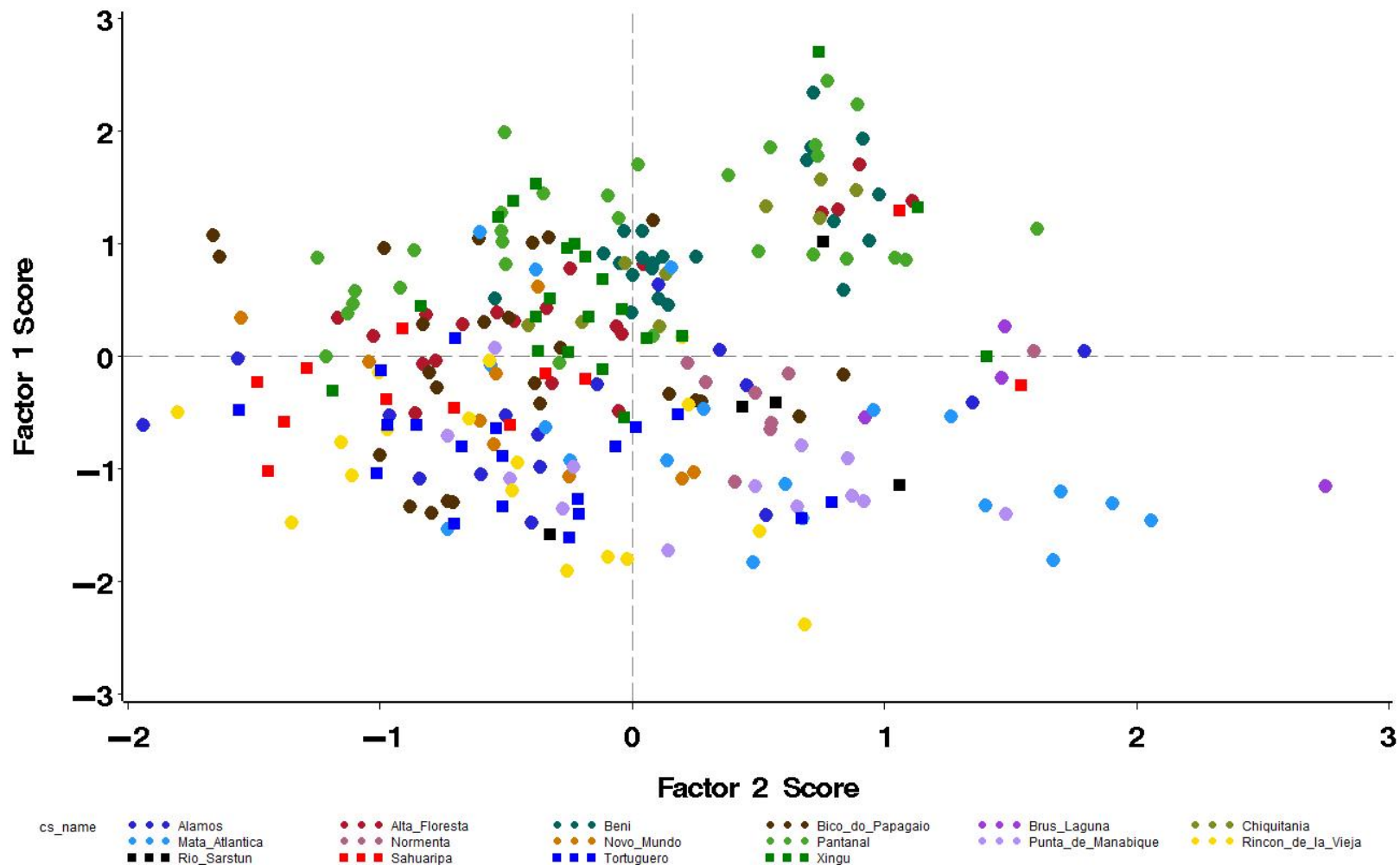


Figure 9: PCA plot showing positions of samples for each case study according to Factor 1 (property size, herd size, economic dependence) and Factor 2 (losses to jaguars, social norms). Two outlying farms on factor 2 score omitted for clarity. [we may also add a plot with just the centroids – means on each axis with SE for the case studies]

Relative rankings of case studies

We might regard those communities to be a priority for action in which we observe relatively low tolerance of jaguars, negative attitudes and negative social norms. Other variables such as the economic dependence of livestock, level of concern about depredation, plus specific indicators such as reported killing of jaguars, and high proportions of livestock losses blamed on jaguars also play a role in assessing whether one case is 'worse' than another, (as does the relative vulnerability of the local jaguar population in each of these, for which we do not have information as part of this study). If we study these various indicators across **Table 4** and **Figures 6** and **7**, we see that there is variation across all these, and no case study scores very negatively or very positively in all of the criteria. If we sum the mean index scores for tolerance, attitude and social norms, the three most negative case studies appear to be: Chiquitania, Beni and Brus Laguna, while the three most positive are Bico de Papagaio, Alta Floresta and the Pantanal (**Table 7**). The killing of jaguars is reportedly very common in the three most negative communities – however, so it is too in the most positive, the Pantanal.

Case study	Mean Tolerance Index	Mean Attitude Index	Mean Norms Index	Sum ¹⁾	People kill jaguars here ²⁾	within JCU or corridor
Chiquitania	3.45	-1.00	-5.00	-2.55	95	JCU
Beni	4.09	-0.39	-5.27	-1.58	100	-
Brus Laguna	6.10	-1.95	-4.05	0.10	90	JCU
Río Sarstún	4.86	-0.90	-3.00	0.96	62	Corridor
Xingú	5.50	0.27	-4.14	1.64	95	-
Punta Manabique	5.38	-0.61	-2.43	2.34	86	Corridor
Novo Mundo	5.55	-0.30	-2.71	2.53	77	-
Sahuaripa	3.70	-0.69	-.07	2.93	47	JCU
Normenta	6.48	0.70	-3.60	3.57	91	JCU
Álamos	4.90	-0.62	.57	4.86	33	JCU
Tortuguero	5.35	-0.05	.30	5.60	25	JCU
Rincón de la Vieja	5.59	-0.61	.64	5.63	7	JCU
Mata Atlantica	5.45	1.10	-.85	5.70	45	JCU
Baritú	6.29	1.52	-1.76	6.04	65	JCU
Bico de Papagaio	6.96	0.76	-1.32	6.40	52	-
Alta Floresta	6.93	2.11	-2.19	6.85	82	-
Pantanal	7.16	2.65	-2.27	7.53	91	JCU

¹⁾ Sum of tolerance + attitude + norms ; ²⁾ Percentage replied "yes"

Table 7: Ranking of case studies in order of overall mean negativity towards jaguars

Discussion

From northern Mexico to northern Argentina, across seventeen case studies of human-jaguar conflict, we could find no strong patterns that allow us to connect any set of circumstances with any set of human behaviours or attitudes. Instead, we found a tremendous range of geographic, agronomic and socio-economic contexts, in heterogeneous compositions of farm sizes, types, economic dependency, education and rootedness, as well as large differences in farmers' experiences with livestock losses and their levels of tolerance and attitudes towards jaguars.

Although some subsets of these variables were correlated significantly with each other in a few cases studies, none could be predicted consistently across all, or even a majority of them. Indeed in some cases, these correlations even followed diverging directions, for example in the Beni, farmers with more livestock were more tolerant of jaguars, but the opposite was true in Alta Floresta. In short, it appears that none of the large number of situational factors we measured can be used to predict how farmers will perceive jaguars and deal with depredation. However, we did find one pattern that appears to be consistent across the range: tolerance and attitude were most likely to be predictable to some extent (weakly in some cases and strongly in others) by a factor of how many livestock a farmer loses to jaguars, combined with how he perceives the social norms of his community.

This has been the geographically largest empirical study of human-jaguar conflict to date - the first systematic search for patterns across seven countries of the species' range. Yet even with this many case studies, we find only one consistent pattern. Perhaps at a much larger scale, involving hundreds of cases studies, one would find more patterns, but these may still be quite weak, and an endeavour of such sampling would become unfeasible. However, sampling limitations aside, this outcome reminds us to be cautious with

generalisations. Much of the scientific literature on human-wildlife conflict is based on case study research, and – just as ours – individual case studies tend to extract a number of interesting relationships of variables. Authors will then customarily support their results by citing other studies with similar findings.

Similarly, if we review the literature for a given topic and find that, for example, in six case studies a certain result was discovered, we may consider this to imply a likely universal truth. Yet this same finding may have not been reported in a number of other studies, and we can't be sure whether it was not non-significant, or simply not studied. There is a tendency, therefore, for us to generalize from a few convincing case examples – the fallacy of hasty generalisation (Walton, 1999) i.e. leaping to conclusions on the basis of insufficient or unrepresentative sample.

Patterns found are meaningful for the context within which they were studied, and useful for informing action at that given local scale. For example, in paired case studies such as those studied by Marchini and Macdonald (2012) it is reported that fear predicts intention to kill jaguars in Alta Floresta, but group identity was the more important variable in the Pantanal, while in both sites, attitudes and social norms also predicted intention to kill jaguars.

It may be that variables not included in this study have more consistent effects across the range. For example, in our expert survey and systematic review (see Chapter 2) we found frequent mention of prey depletion as the main driver in triggering jaguar predation on livestock. Similarly, in an earlier review of human-wildlife conflict situations of the nine largest wild cat species we found that ecological predictors such as habitat and wild prey availability were consistently mentioned across the literature, but spatial-temporal and

socio-economic characteristics varied considerably, suggesting that each conflict situation may be unique (Inskip & Zimmermann, 2009).

Unfortunately such case-uniqueness does not make the job of mediating human-wildlife conflict easier, especially for species where this threat is widespread and requires more action than resources allow. When faced with such unwieldy tasks, we try to categorise, simplify, model, reduce and predict things. This study reminds us that such generalizations are not likely to be fruitful. But there is another way forward – one which is confluent with a general trend in conservation science: to become masters of interdisciplinarity, with a special awareness of the need to ‘think like humans’ (Adams, 2007) (and see Chapter 5), and for those schooled in life sciences to become comfortable with theories, such as the theory of planned behaviour, (Ajzen & Fishbein, 1980), about human behaviour established in the social sciences.

We can learn about processes rather than predictive rules, learning about the communities with which we are dealing, how to interpret any underlying issues and how to accept the unpredictability of each scenario, knowing the right questions to ask and to think more creatively than logically about possible solutions. The best way to speed up human-wildlife conflict mitigation therefore, may be not by understanding predictable patterns, but by understanding typical processes and knowing the right questions to ask to get to the local heart of the matter efficiently.

We did find a weak effect suggesting that, generally, tolerance of jaguars is predicted by a combination of positive social norms and low losses of livestock. This is good news. It gives us clear and feasible instructions on what we need to do to resolve human-jaguar conflict.

First, there are tried and tested methods for reducing the impact of jaguar depredation, ideally through a combination of reducing actual mortality of livestock (through better protection and deterrents) and by increasing overall productivity of livestock (through better husbandry and veterinary care), which offset losses to jaguars and make it a risk so negligible that it becomes economically tolerable. This type of work has been carried out in particular on large ranches in the Pantanal and Venezuela, with technical manuals provided, for example, by Hoogesteijn (2005) and possibilities of drawing on government or NGO agricultural assistance existing in most of the relevant regions. Second, having understood that social norms are so important in conservation psychology, (Manfredo & Drayer, 2004; St John et al., 2010; Marchini & Macdonald, 2012 and see Chapter 5) we can focus our efforts on these. Attitudes and behaviours can be influenced, for example with social marketing approaches, i.e. the use of marketing techniques to create values and influence behaviours to the benefit of the target audience (McKenzie-Mohr, 2000).

Beyond the recommendation to focus efforts on improving livestock-based livelihoods and influencing social norms, we have to conclude that each case of human-jaguar conflict is indeed likely to need individual treatment. In each there are different stakeholders, values, identities, histories, socio-political factors and opportunities. Insights from wide-ranging studies such as this can give us helpful familiarity with the range of possible scenarios that exist, adding breadth of information to depth of local knowledge. A thorough overview of the kinds of scenarios and solutions that exist elsewhere is helpful for developing local strategies. Implementing these on the ground, however, requires the experience, relationships and intuition of a local expert working with the affected people in each specific case.

Acknowledgements

A study of this geographic scale requires a large team of collaborators. Logistical facilitation, advice for field work, and assistance with recruitment of field team members were provided by Claudio Sillero, Jose Soto-Schoender, Pablo Perovic, Carlos Lopes-Gonzales, Erika Cuellar, Daniel Corrales, Franklin Castañeda, Ronit Amit, Rogerio de Paula and Howard Quigley. The survey interviews were administered in the field by: Karla Camargo and Claudia Moreno Arzate in Mexico, Lorena Lobos in Guatemala, Mario Ramos Solis in Honduras, Pablo Cuellar in Bolivia, Alan Eduardo de Barros, Tiago Henicka, Ronit Amit and Alejandro Matthey Trigueros in Costa Rica, and Pablo Perovic in Argentina. Further local field advice was provided by Sandra Cavalcanti, Silvio Marchini, Ricardo Bolhousa, Tadeu de Oliveira, Francesca Palmeira, Emerson Villaba and Elizabeth Leite. Samantha Earle, Carmen Quiroga Pacheco and Alan Eduardo de Barros assisted with data entry and checking. Data analysis was guided by Paul Johnson. Brian McQuinn advised on survey question design, Silvio Marchini reviewed survey drafts. Erika Cuellar and Silvio Marchini translated the surveys into Spanish and Portuguese. Chester Zoo provided accounting and administrative support; *Panthera* provided vehicle use in Costa Rica. This project was a collaboration of the Wildlife Conservation Research Unit of Oxford University and the Field Programmes Division of Chester Zoo, and was funded by Chester Zoo.

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Deconstructing human-jaguar conflict

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Deconstructing human-jaguar conflict

Abstract

Conflicts between people and wildlife are common worldwide and present a serious threat to the survival of many charismatic large species. These conflicts vary in their characteristics and levels of complexity and often obscure deeper socio-political issues which may considerably hinder conservation efforts. In Chapter 4, the analysis of seventeen case studies of human-jaguar conflict in seven countries revealed that patterns of conflict could not be predicted by any single factor such as economics, farmer type, education, attitudes towards jaguars or conservation, or social norms. Each scenario of conflict was unique and varied in its complexity. In the analysis below we propose a conceptual model that distinguishes between three levels of conflict: dispute, underlying, and deep-rooted. Dispute-level conflicts can be settled with practical interventions, while underlying conflicts necessitate addressing an unresolved history of grievances, and deep-rooted conflicts require reconciliation of differences in values and beliefs. Approaches for mitigating these situations must be appropriate for the level of conflict involved. In this paper we illustrate the utility of this model for facilitating human-jaguar conflict mitigation.

Introduction

Conflicts between people and wildlife are common worldwide and often involve charismatic, endangered species such as the big cats, wolves, bears and elephants (Kellert et al., 1996; Mech & Boitani, 2003; Thirgood et al., 2005; Inskip & Zimmermann, 2009). In many cases such conflicts present a serious threat to the species' survival (Woodroffe et al., 2005c; Dickman et al., 2013). By posing a recurring threat to people by killing livestock, damaging crops, or attacking people, they may be persecuted to the point of local extinction (Woodroffe et al., 2005c).

The perception that wildlife is responsible for income losses can be sufficient to trigger retaliatory killing of the blamed species, regardless of the real extent of the damage (Macdonald, 2013; Treves et al., 2013). Tolerance of the species is not necessarily linked to the actual losses (Liu et al., 2011; Suryawanshi et al., 2013). From a conservation point of view, therefore, we sometimes have to consider the farmer's perception of the situation to be more important than its reality.

Efforts to mitigate human-wildlife conflicts do not always succeed, even when the apparent problem or dispute has been addressed by reducing the economic losses (Rabinowitz, 2005). Conflict resolution requires an interdisciplinary effort and biologists are increasingly looking to social science for guidance (Macdonald et al., 2010). Although fully aware of the importance of human dimensions in conservation, their understanding of it is often based on intuition rather than formally learned theories about human behaviour (Adams, 2007). Conceptual models and structured examples can therefore be helpful, particularly in human-wildlife conflicts, where there are often seemingly unrelated issues at stake.

Human-wildlife conflict situations are generally complex (Dickman, 2010), but some situations appear to be easier to address than others. In the Indian state of Assam, for

instance, wild elephants raid crops, damage buildings, and occasionally kill people (Zimmermann et al., 2010b). The impact for communities is detrimental, a matter of life-and-death for farmers in poverty who may lose their entire livelihood to elephants in a single night (Zimmermann et al., 2009; Wilson et al., 2013). Yet most of the affected communities have a strong culturally-driven tolerance of elephants and are eager to work with conservationists to find solutions. This is a conflict that can largely be resolved with practical measures, such as community-based interventions of fencing and deterrents (Davies et al., 2011; Zimmermann et al., 2013)

In other cases, however, efforts to address the apparent dispute without considering the underlying socio-political conflicts affecting the situation may result in only temporary fixes, or worse, exacerbating the tensions (Breitenmoser et al., 2005; Thirgood et al., 2005; Webber et al., 2007; Dickman, 2010). In these situations, there is more at stake than the visible concern over income loss. This situation usually arises when a history of unresolved disputes accumulate, leading to resentment and desire for 'justice' when new problems arise (Lederach, 2003). Critically, it is only necessary for one of the parties to perceive previous disputes in this way - the other party, for example conservationists, may have considered the issue satisfactorily addressed. Over time, underlying conflicts become more pronounced and intractable. This is especially the case when disputes are perceived to threaten the values or identity of one of the parties, leading to an accumulation of grievances, social identities and conflicting beliefs (Lederach, 1997).

An example of how conservation can impact social identity is seen in the case of wolves. Both in Europe and in North America, wolves are the subject of some of the most intractable human-wildlife conflicts (Treves et al., 2013). Attitudes towards wolves are especially negative among ranchers and sheep farmers, to the extent that in Norway and France farmers suspected that the government was secretly reintroducing wolves into their

region (Skogen et al., 2008), while in Slovakia, hatred of wolves continues even though actual depredation on sheep has been reduced to a negligible level (Rigg et al., 2011). Even financial compensation does not improve tolerance levels (Treves et al., 2013). These conflicts are embedded in wider issues of social change, where cooperation between stakeholders has deteriorated (Bisi et al., 2007; Skogen et al., 2008). Wolf conflict is described by several authors as value-based (Nie, 2002; Bisi et al., 2007), i.e. there are deep moral differences over a symbolic animal in a complicated political and cultural context (Nie, 2002). Value-based conflicts cannot be settled with practical solutions (Bisi et al., 2007), they require approaches to reconcile the incompatible beliefs and values or identities.

Social scientists studying conflicts employ various conceptual models to analyse the intensity, progression, and resolution of conflict (Lewicki et al., 1992; Ramsbotham et al., 2005). One model originated by the Canadian Institute for Conflict Resolution (CICR, 2002) and adapted to human wildlife-conflict by Madden and McQuinn (*in press*) distinguishes between three levels of conflict: *dispute*, *underlying*, and *deep-rooted*.

A conflict is not usually obvious to an observer unless there is a problem at hand that is being contested by two or more parties. This is the presenting *dispute*, which frames the conflict, its parties and what is at stake. Yet in conservation, as in many other types of conflicts, there is often much more at stake than is obvious to the casual observer, influenced by pre-existing relationships and history among the parties. A history of previous disputes that were not satisfactorily resolved can consciously and unconsciously affect the parties involved in the dispute. This intensifies the conflict over the presenting dispute and is described as *underlying* conflict. A hypothetical example may help distinguish between the *dispute* and *underlying* levels of conflict:

The example involves jaguar depredation on two ranches of approximately the same size and with the same number of cattle. On the first ranch, the jaguar attack is the first such incident. The rancher is concerned about the loss but open to discussing mitigation options and is willing to accept assistance from 'outsiders' like conservationists. In this case the dispute is relatively straightforward. In contrast, imagine a second ranch with the same characteristics, but in which the incident of depredation is only the most recent in a string of what has become a recurring issue. The rancher has complained to the authorities, who took some measures but the problem was not satisfactorily resolved. In this situation, the history of the dispute adds to its depth, for example, the rancher's irritation about a third party's behaviour makes him increasingly resentful and could, for instance, lead to exaggerations about the impact of depredation. This tension and perception of injustice increases what is at stake in each new incident. In both examples, however, the presenting dispute is exactly the same: an incident of jaguar predation.

The final level, deep-rooted or identity-based conflict, is the most intransigent. At this level the presenting dispute threatens the social identity or values of one of the parties, and this raises the stakes considerably. Returning to our rancher example, imagine a third ranch again of the same parameters, except in this case the single incident of depredation is not only another in a long history of problems, but a reminder that the presence of jaguars in the region is the result of a government initiative that the ranching community had opposed in the first place. In this situation, each new incident of depredation not only exacerbates the history of unresolved issues, but from the rancher's perspective the jaguar becomes a symbol of the government's disregard for the ranchers' way of life. In this situation, jaguar depredation becomes a struggle over power, identity and values.

In all three cases, the presenting dispute was identical – an incident of depredation – but the intensity and perceived consequences of each was significantly different. This presents a challenge to conservationists, as underlying and deep-rooted conflict are not usually obvious (even if one can usually sense that ‘something else’ is going on). The levels of conflict concept provides a model to disaggregate the different conflict dynamics and provide a structured approach for testing what is otherwise only intuition.

In a previous study (Chapter 4) we conducted seventeen case studies in seven countries in order to identify patterns in human-jaguar conflicts across the range. This tested a very large variety of geographic, agronomic and socio-economic contexts, farm types, extents of losses to jaguars, economic dependency on livestock and education levels. Both within and across the case studies there were considerable differences in farmers’ experiences with livestock losses, concerns about depredation, levels of tolerance and attitudes, as well as social norms towards jaguars. No situational factor on its own could predict how farmers perceive jaguar depredation, although tolerance was in most cases influenced by a factor of perceived losses of livestock combined with the influences of peers.

As part of that survey, we asked targeted questions to identify the levels of conflict present for each respondent. This is measured through an index of specific responses and tested for correlations and predictive variables associated with it. We then provide guidance in how to identify levels of conflict in a given situation and consider the most appropriate mediation approaches for each.

Methods

Survey Design

To illustrate our model of levels of conflict, we used data collected for a comparative analysis of human-jaguar conflicts across the species' range (Chapter 4). In this, we interviewed around 400 farmers about their experiences with depredation by jaguars, in 17 different sites in seven countries of the jaguar range (Mexico, Guatemala, Honduras, Costa Rica, Brazil, Bolivia and Argentina) – see Chapter 4.

The aim of this aggregate case study, in which we systematically gathered the same data from a variety of human-jaguar conflict settings, was to search for broad patterns across the species range, rather than an in-depth cause-and effect account of each scenario. The survey included questions about the respondent's background, information about the farm and livestock management, quantifications of losses of livestock, perceptions about such losses, opinions about, and reactions to, jaguars, and options for mitigation. Details of the questionnaire design and sampling strategy are explained in Chapter 4.

The survey was designed so that certain sets of related questions could be combined to form measureable indices. These included indices of economic dependence on livestock, levels of concern over depredation, tolerance of depredation, attitudes towards jaguars, and social norms of reactions to disturbances by jaguars.

We also included specific questions for assessing the different levels of conflict perceived by each respondent (see Appendix 2 for full questionnaire wording). Likert scales were used for the following value statements: "Jaguars threaten my way of life" (Q23); "I don't trust conservation people" (Q52); "My values differ from those of conservation people" (Q53); and "The government cares too much about jaguars" (Q54). We also asked them to

describe jaguars in three words (Q25), and state their preferred outcome for the jaguar species, ranging from extinction to having more jaguars in their area (Q32).

Data Analysis

As in Chapter 4, the survey responses were re-coded into numerical categories and analysed descriptively in SPSS (PASW Statistics, v.21, 2012) with multivariate analyses carried out in SAS (v. 9.3, 2011, SAS Institute Inc., Cary, NC, USA). We applied a Principal Components Analysis (PCA) to summarise patterns in size of farm, number of livestock, proportion of land used for livestock, education levels, social norms, tolerance levels, and concern about depredation. The factor scores were then used as responses in GLM models with levels of conflict. We used the identity of the case studies as a categorical predictor to allow for among-case variability in the response. The interaction terms involving case study were also included to test the hypothesis that the effect of predictors on the response varied among case studies (a 'significant' result for the interaction term indicating evidence for variation in the patterns between case studies).

Results

Survey data collection took place between August 2011 and February 2012, in 17 case studies across Mexico, Guatemala, Honduras, Costa Rica, Brazil, Bolivia and Argentina (see Chapter 4). For each case study, between 20 and 32 interviews were conducted (mean 24, total 409).

We calculated depth of conflict by scoring a farmer's responses to the Likert statements '*jaguars threaten my way of life*', '*I don't trust conservation people*', '*my values differ from those of conservation people*', and '*the government cares too much about jaguars*,' as well as their descriptions of jaguars and their preferred outcome for the species. An additive score of these responses gave us an index of depth of conflict and a score between -9 and +9. **Figure 1** shows the range scores for each of the case studies.

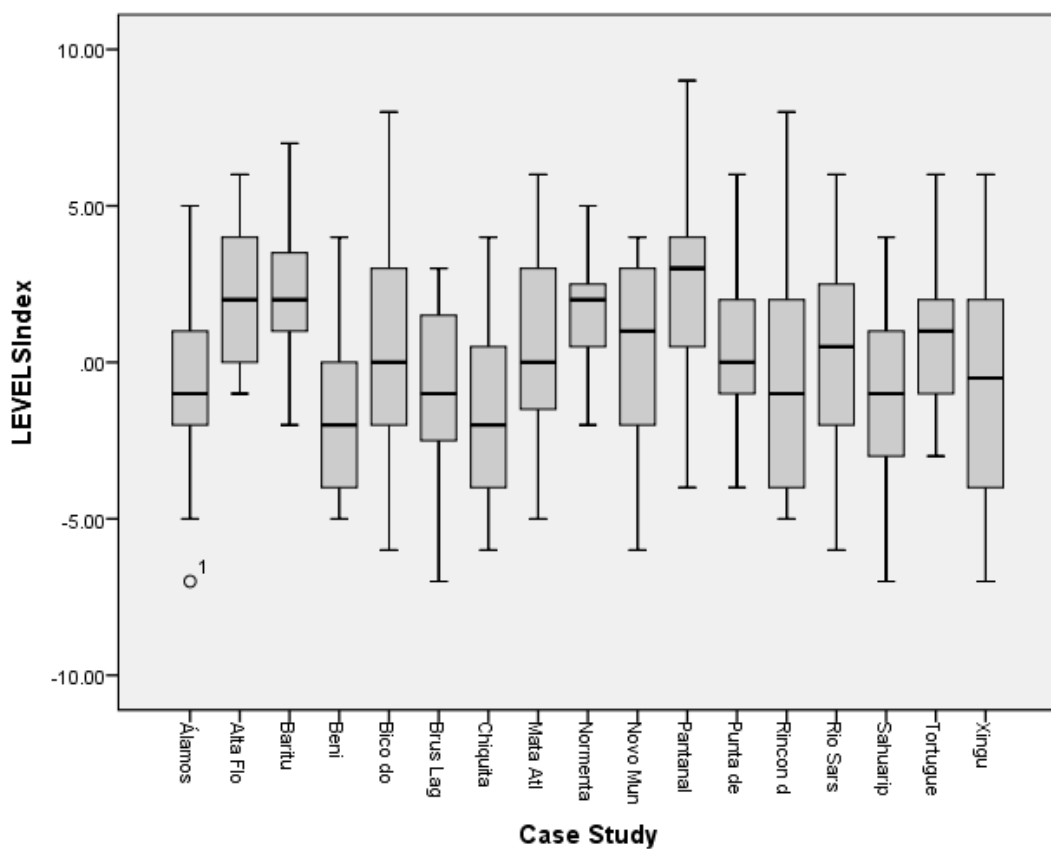


Figure 1: Depth of conflict scores for each case study.

If we group scores equidistantly, from -9 to -4 as 'deep-rooted', -3 to +3 as 'underlying', and +4 to +9 as 'dispute-level', we see that the distributions of these levels varies across the case studies (**Figure 2** and **Map 1**). In Alta Floresta, Baritu, Normenta and Tortuguero there appears to be no deep-rooted conflict at all, while the Beni, Chiquitania, Rincon de la Vieja, and Xingú more than 20% of respondents replied in ways that suggest deep-rooted conflict.

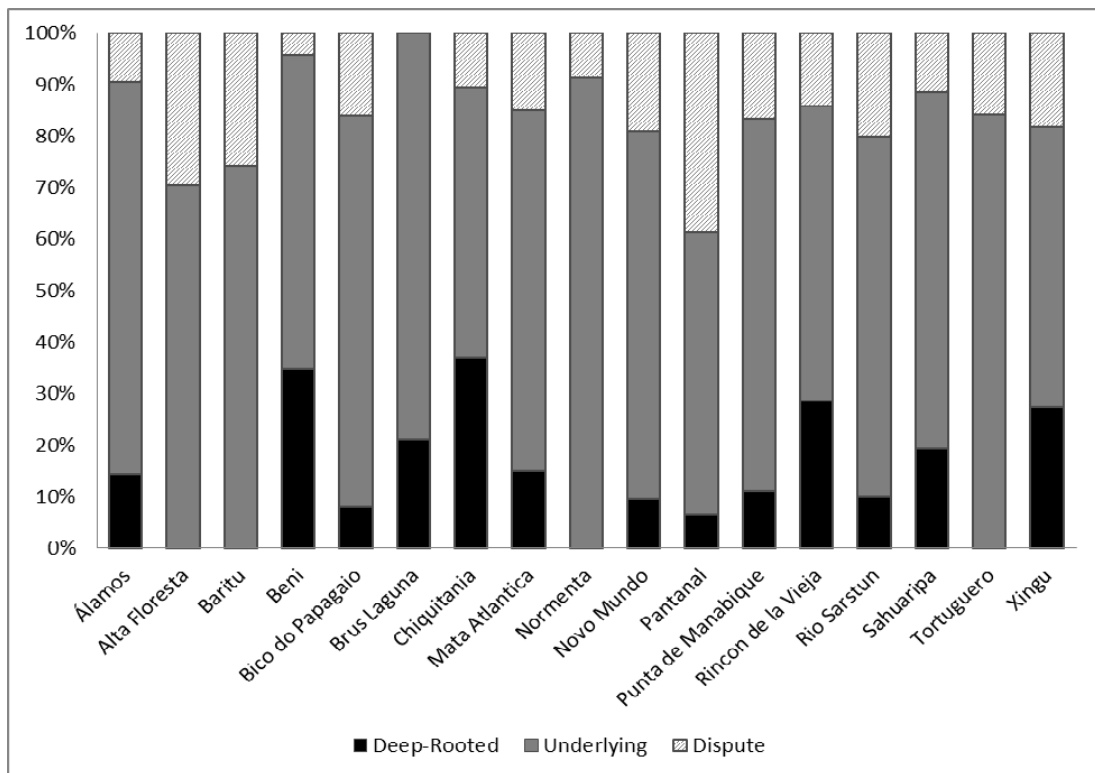
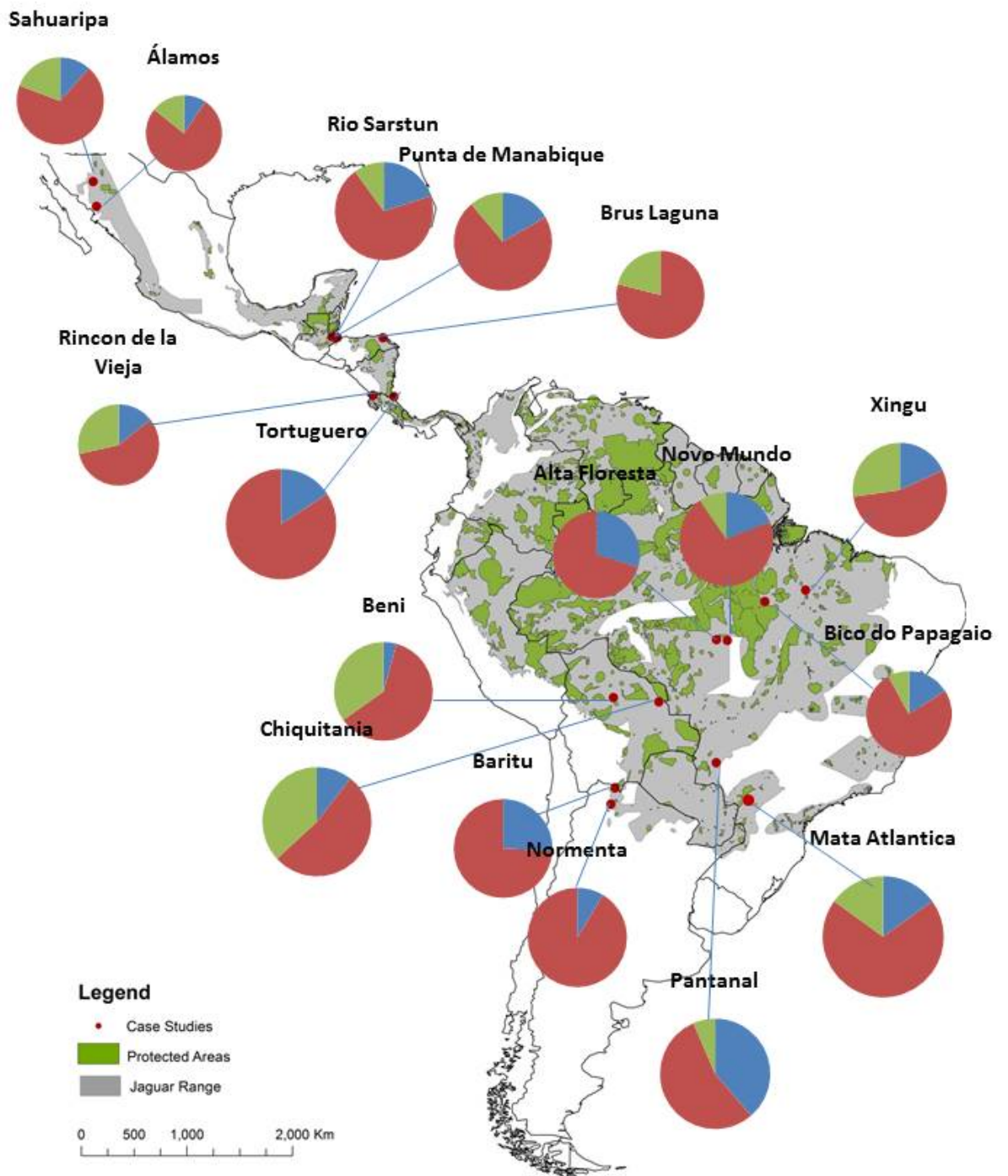


Figure 2: Occurrence of the three levels of conflict in each of the case studies

When we analyse the responses of individual farmers we find that the level of conflict is not consistently correlated with single variables such as *economic dependence on livestock*, *actual losses*, or *history of conflict*, nor *education*, *age*, *tolerance of jaguar depredation*, *attitudes towards jaguars*, *attitudes towards conservation*, or *social norms*.



Map 1: Occurrence of the three levels of conflict in each of the case studies. Blue = dispute, red= underlying, green = deep-rooted.

We then carried out a principal component analysis (PCA) with the variables *age*, *education*, *property size*, *number of livestock* (square root), *proportion of land used for livestock*, *economic dependence on livestock*, *concern about depredations*, *tolerance of jaguars*, and *social norms*. Here we find that high scores on Factor 1 are associated with larger farms and more livestock, higher education levels and more negative social norms, while high Factor 2 scores are associated with more tolerance of jaguars, less concern about depredation, and smaller proportions of farmland used for livestock (**Table 1**).

Factor Pattern	Factor 1	Factor 2
Age	-0.35763	0.19852
Education	0.60189	-0.26389
Farm size	0.75510	0.39979
Number of livestock	0.86677	0.27876
Land used for livestock	-0.06547	-0.66774
Economic dependence	0.44955	-0.27552
Concern about depredation	0.24388	-0.44303
Tolerance of depredation	0.06860	0.54455
Social norms	-0.45959	0.35432

Table 1: Correlations between input variables and ordination scores. The eigenvalues for factors 1 and 2 were 25.5% and 16.5% respectively.

A plot of the factor scores coded by dispute level suggests some segregation on these axes, principally the second (**Figure 3**). The factor scores were used as responses in GLM models with both case study identity and level as categorical predictors. The interaction terms were non-significant for both factors, indicating little evidence that the relationship between factor score and level differed between case studies ($F_{24,206} = 0.55$, $P = 0.96$, and $F_{24,206} = 1.51$, $P = 0.07$ respectively). The main effects of both case study and level were significant for both axes. (For factor 1: $F_{15,230} = 12.4$ $P < 0.001$ for case study and $F_{2,230} = 3.32$, $P = 0.04$ for dispute level. For factor 2: $F_{15,230} = 11.9$ $P < 0.001$ for case study and $F_{2,230} = 7.4$, $P = 0.0008$ for dispute level). The scores on both axes descend in the order deep-rooted, underlying, dispute. All three levels are distinct for axis 2 (Tukey means separation procedure).

Therefore we observe some tendency for those who show signs of deep-rooted conflict to be more educated, larger landowners with larger herds of livestock (i.e. ranchers rather than smallholders) in communities where the social norms about jaguar persecution are negative. The stronger pattern however, is shown by Factor 2 which suggests that farmers with deep-rooted conflict characteristics are those who use a larger proportion of their land for livestock, have lower tolerance of jaguars, and worry about depredation more (**Figure 3**).

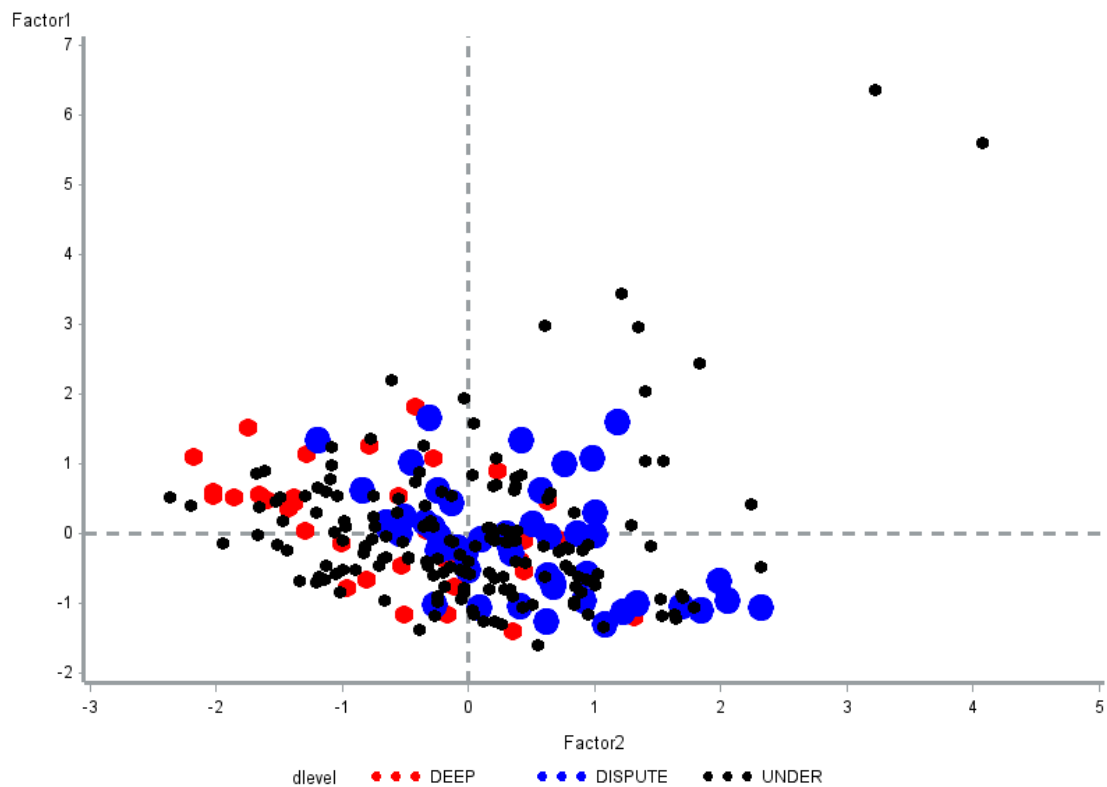


Figure 3: PCA plot showing the positions of respondents according to a factor of property size, livestock holdings, education levels, and social norms (Factor 1, y-axis) and proportion of land used for livestock, tolerance of jaguars, and concern about depredation (Factor 2, x-axis).

Discussion

According to the levels of conflict model and as illustrated through our example of over 400 respondents across 17 different regions of human-jaguar conflict, farmers perceive conflict with three levels of intensity: merely as a dispute over lost livestock; a more complicated issue with a history of unresolved disputes; or a deep-rooted, ongoing battle, infused with identity, tradition and conflicting values about matters that are unlikely to be directly related to the loss of livestock itself. Levels of conflict were not correlated with actual losses or economic dependence on livestock, nor the length of time a farmer has experienced such losses. Nor were they correlated with attitudes towards jaguars or towards conservation in general.

While no single variable on its own could predict the level of conflict, the PCA shows that farmers with larger properties and more livestock, who are more educated and in whose communities the social norms about jaguars are more negative (Factor 1) and who use most of their land for livestock, worry about depredation and have low tolerance of losses (Factor 2), were more likely to show signs of deep-rooted conflict. These are characteristics typical of cattle ranchers, and so we might cautiously infer that conflict with ranchers is more likely to be deep-rooted. Indeed, looking at the distribution of conflict levels in Figure 2, the case studies with the most deep-rooted conflict were the Beni, Chiquitania, Rincon and Xingú - regions which do contain more large farms than smallholdings.

However, our lesson from Chapter 4 was that one cannot generalise from case studies, and the conflict model too urges us to look closely at each situation individually. Furthermore, the Pantanal, a region famous for its rancher-jaguar conflict appears in our analysis to have very little deep-rooted conflict, and in our previous study (Chapter 4) turned out to present some of the most positive attitudes towards jaguars. We may speculate that this could be the result of a long history of conservationist presence in the region and the lessons learned

there in the field. Experience from the Pantanal e.g. (Marchini, 2002; Rabinowitz, 2005; Cavalcanti et al., 2010) has taught us that collaboration with ranchers is about process, co-investment, and developing relationships in which they make the decisions (Rabinowitz, 2005; Sillero-Zubiri et al., 2007).

For effective human-wildlife conflict mediation, a key step of such a process must be to understand the levels of conflict operating in that particular environment (Madden & McQuinn, *in press*). To get to the heart of the matter quickly, there are certain signs or indicators that help identify the level of conflict for a given scenario. The dispute component is always present, otherwise there would be no conflict, but it may obscure deeper issues that are often not immediately apparent. Treating only the dispute, for example by drastically improving livestock protection, will not change the situation in any significant way if there is an underlying history of grievances or a deeper friction of values and identities. To uncover those, there are key questions one can ask, which reveal indications that point to underlying or deep-rooted conflict. For example, at the dispute level, a farmer would in conversation be interested in suggestions of practical assistance, while at the deep-rooted level, he would talk more about who is to blame and seem disproportionately troubled about the issue.

To assess a given human-wildlife conflict, researchers generally quantify losses, examine spatial or temporal patterns, describe socio-economic characteristics, and measure attitudes. Indeed, attitudes are the most-studied human dimension in human-wildlife conflict research (Manfredo & Drayer, 2004), but they alone do not directly determine behaviour (Verissimo, 2013). Attitudes are one important explanatory variable, but behaviour is also determined by norms and perceptions of control (Ajzen & Fishbein, 1980; Ajzen, 1991; Manfredo & Drayer, 2004), so their measurement as a proxy for behaviours is of limited use in applied conservation (St John et al., 2010). Instead, the researcher needs

to gain insight into the farmers' values and beliefs (Cavalcanti et al., 2010). Conflict resolution can only succeed once the drivers of behaviours and the socio-political and cultural contexts of a given situation are understood (Mascia et al., 2003; Rabinowitz, 2005).

Interviews or surveys, as used in our study can be useful in situations where a rapid assessment is needed. They give an initial indication of the levels of conflict perceived by the different parties involved in the situation. If the result of initial conversations with the farmers suggests underlying or deep-rooted conflicts, additional in-depth enquiry (e.g. in the form of participant observation, focus groups and other methods) will be a necessary component of the conflict mitigation process that follows.

To test for underlying or deep-rooted conflict, questions should focus on exploring values, as well as the history of the problem, which amplifies the potential for deeper conflict. The questions should explore: a) history of attempts to mitigate losses; b) perceptions about previous efforts by third parties; c) attitudes about interactions with those third parties; d) values compared to conservation ideals; e) perceptions about other stakeholders involved in the situation; and f) other socio-political conflicts between the stakeholders, even if not directly related to conservation issues.

In **Table 2** we summarize the difference in approaches that are needed for each conflict level with indicative responses to some of the questions posed above and the corresponding mitigation processes.

Level	Indicators	Approaches / Processes
Dispute	Farmer complains about income loss or concerns about safety Is open to receiving help and cooperating with trials for solution Willing to adapt habits and cooperate with interventions Responds positively or neutrally to questions about jaguars	Practical solutions to protect income and security (e.g. barriers, alarms, husbandry improvements) Reduce depredation to a level acceptable to the farmer by adapting livestock husbandry and increasing productivity or diversifying income sources to off-set losses
Underlying	Farmer dislikes or fears jaguars and would prefer not to have them around Frequency and impact of losses may be exaggerated There is a history of unresolved losses or resentment about the actions of authorities/third parties An expectation that someone else has to solve this issue /compensate	Conflict can be resolved with practical solutions as above, but in combination with approaches to influence behaviours, such as social marketing. Focus on building relationships between the stakeholders. Ensure initiatives address past issues in practical or symbolic ways.
Deep-rooted	Farmer expresses strongly negative opinions about jaguars and will not tolerate their presence in the area Unwilling or reluctant to change his ways, blames someone or something (e.g. government/policies). Uses polarized language, e.g. “us against them”, generalizations, “always/never” statements The intensity of expressions about the species seems disproportionate to the apparent extent of the problem	Addressing conflict at this level usually involves dialogue processes that balance power amongst the parties and empower communities. The emphasis must be on re-balancing decision-making, ownership and co-investment. Symbolic gestures demonstrating respect afford stakeholders dignity that is often perceived to be lacking.

Table 2: The levels of conflict, their indicators and appropriate mitigation approaches.

Disputes, which are about negotiable interests, can be approached through negotiation, resulting in settlements acceptable to all parties involved (Ramsbotham et al., 2005). In our scenario with jaguars and ranchers this could involve, for example, helping the rancher access better veterinary care, build more protective night enclosures for cattle, and increase the overall productivity of his stock, to off-set any future losses to carnivores.

Addressing underlying conflict requires approaches that explicitly address the history of disputes and searching for common ground among the parties. Practical solutions are still relevant, but these need to be combined with approaches that address behaviour change, such as social marketing, i.e. the use of marketing techniques to create values and influence behaviours to the benefit of the target audience (McKenzie-Mohr, 2000). There also needs

to be a focus on building relationships among the stakeholders in order to ensure future incidents are addressed proactively.

Engaging with deep-rooted conflict is the most challenging as the parties perceive its outcome to impinge on their values, identities, or way of life. Given that many values or beliefs are immutable, suggestions of negotiation or compromise can exacerbate the situation. As this level of conflict often concerns power, decision-making and perceived ownership over the resources in question, addressing the conflict usually requires long-term processes of facilitated dialogue that balances power amongst the parties and reassigns decision-making, ownership, investment and responsibility among the stakeholders.

Each case of conflict is unique, shaped by a range of variables, and even within cases there are no clear patterns or rules to be followed. Therefore, the only way to improve our rate of success in managing human-wildlife conflicts is to become better at understanding the dynamics and influencing forces of each case efficiently and devise an appropriate approach of response.

Acknowledgements

The data in this study formed part of a larger study on human-jaguar conflict, carried with many collaborators (see Chapter 4). Guidance with statistical analysis was provided by Paul Johnson. This project was a collaboration of the Wildlife Conservation Research Unit of Oxford University and the Conservation Division of Chester Zoo, and funded by Chester Zoo.

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Conclusion

In this thesis I have attempted to distil what is needed to mitigate the threat of conflict to the survival of the jaguar across its 19 range states. I carried out an expert survey and a systematic review of empirical studies to assemble a most comprehensive synthesis of the current state of knowledge on human-jaguar conflict. By combining geospatial datasets of the jaguar range, protected areas, livestock densities and human geography with this expert-based information, I characterised the main spatial patterns of human-jaguar conflicts and presented a conflict risk map for the species' range. This was followed by a series of field case studies of farming communities across seven countries. Analyses of these case studies demonstrated the variety of situations and contexts that exist and prompted a discussion about the extent to which local-level insights can inform range-scale strategies. Finally, I described a conceptual model to help us understand some of the complexities of the human dimensions of conflict. In this final chapter I revisit the research questions set out in the Introduction, and summarise the answers and conclusions to each.

1) The state of knowledge about human-jaguar conflict

In what geographical and socio-economic contexts do conflicts occur?

Human-jaguar conflict occurs in all range states, on large cattle ranches as well as on small farms. They involve multi-generational ranching operations as well as medium-sized farms with mixed income sources and smallholdings of migrant settlers and indigenous communities. The cases described in our expert survey and in the literature were located

both inside and outside of protected areas, and most were in tropical lowland forest or lowland grasslands.

What aspects have been studied, where, and at what scales?

Published studies over the past 30 years have investigated livestock depredation patterns, husbandry practices, economic impacts, persecution and killing of jaguars, farmers' attitudes and perceptions, depredation control methods, spatial patterns, jaguar feeding ecology and patterns of prey availability. The information is geographically clustered – the majority of studies have taken place in northern Mexico, Guatemala, Belize, Costa Rica, Venezuela, Colombia, the Brazilian Pantanal, the Amazon of Mato Grosso, Iguazu, northwest Argentina, and the Chaco. The vast majority of studies have been carried out at the case-study scale, which involved single large ranches, or entire ranching regions, as well as smaller communities.

What patterns or predictors of depredation have been observed?

Depletion of wild prey and poor livestock husbandry are repeatedly reported as the key reasons for depredation, regardless of ecological, cultural or socio-economic context. At finer scales, however, we see observe that: a) not all farmers are affected equally within any given region or community; b) not all jaguars prey on livestock to the same extent; and c) not all famers within a community hold the same attitudes about jaguars.

What do we know about attitudes, and tolerance or killing of jaguars?

Farmers' attitudes are often not in direct proportion to the actual impact of losses to jaguars. Communities which fear jaguars have the lowest levels of tolerance. In some regions, such as among Pantaneiro ranchers, cultural motivate drive the killing of jaguars. However, attitudes alone do not determine behaviour; other factors such as social norms and perceptions about farmers' options, are also key to influencing intention to kill jaguars.

What solutions and mediation approaches have been recommended?

Experts widely recommend improvements to husbandry, better protection of livestock and increasing livestock productivity, as almost a default course of action for mitigating human-jaguar conflict. Many also convey the urgency of protecting natural prey. Few discuss the importance of changing people's behaviours in depth, most only mention this peripherally. However, the most recent studies have begun to investigate and explain the importance of human dimensions in any human-jaguar conflict mitigation strategy.

2) Spatial patterns of human-jaguar conflicts

How much of the jaguar range overlaps with livestock, people and protected areas?

Most (65%) of the jaguar range is outside protected areas and 85% has some degree of overlap with livestock (45% of the range contains cattle). Most of the range has very low densities of people and a low human footprint index.

Are there any apparent hotspots of risk for conflict?

Around 15% of the jaguar range contains some risk of conflict, of which 10% is high risk. There are number of distinct hotspots, including: the Sonoran rangelands and parts of western Mexico, the Maya Biosphere Reserve in Guatemala, southern Belize, eastern Honduras and Nicaragua, the Choco-Darien from Panama to Colombia, the Llanos of Colombia and of Venezuela, the grasslands of Roraima and the Rupununi of Guyana, the Pantanal, parts of the Beni and Chiquitania of Bolivia, the Bolivia-Paraguayan Chaco, and areas of Cerrado and Caatinga in Brazil.

How do Jaguar Conservation Units and the Jaguar Corridor fare against such hotspots?

We found that 85% of the total jaguar range, 72% of the total Jaguar Conservation Units (JCU) area and 90% of the Jaguar Corridor total area overlaps with livestock to some degree. The Jaguar Corridor, which links protected areas and JCUs, appears to avoid conflict risk areas well, as 89% of these corridors are risk-free. Of the Jaguar Conservation Units, 77% are risk-free, but those that aren't tend to be high-risk.

Which regions and countries have the most risk of conflict?

Proportional to the jaguar range area they contain, the range states with the most risk of conflict (>20%) are Costa Rica, Belize, Colombia, Guatemala, Honduras and Nicaragua. Those with least risk proportional to their jaguar ranges (<6%) are Peru, French Guiana, Guyana and Suriname. The two strongholds of jaguar populations – the Pantanal and the Amazon – are both areas of conflict risk: virtually all of the Pantanal is a hotspot of high risk, while in the Amazon there are extensive scatterings of risk rather than distinct hotspots.

Where might conflict emerge in future?

Conflict risk appears very low in corridors because we used JCUs as a proxy for jaguar source populations. As a result, risk within corridors occurs where they intersect JCUs. Corridors that become 'successful' in terms of being used by jaguars in future, run a high risk of becoming conflict hotspots. Protected area boundaries, are and will continue to be, high-risk areas for human-wildlife conflict. These edges can become ecological traps or attractive sinks (risky habitats that are tempting for species because of their short-term benefits but are otherwise not optimal for long-term survival).

3) How cases of human-jaguar conflict differ from each other

What variety of human-jaguar conflict scenarios exist across the range?

Conflicts occur in a great range of agronomic and geographic contexts, and range from small farms with just a few livestock, to ranches of over 40,000ha with tens of thousands of cattle. Affected farmers are of varied backgrounds in terms of culture and rootedness, and rely on various proportions of livestock-raising and agriculture or other livelihoods. Attitudes towards jaguars and tolerance of losses ranged from very negative to very positive and were usually not consistent within one community.

How unique are cases of human-jaguar conflict?

A number of cases share characteristics that make them appear similar, for example the expansive cattle ranching areas of the Pantanal, Beni, and Sonora. On closer inspection, there are marked differences among them, for example the ranchers of the Beni were the most negative towards jaguars, and those of the Pantanal the most tolerant of all case studies. Within scenario there were various correlations among the variables measured, but no patterns were consistent across even a majority of cases. Cases are therefore unique, even when they appear to be governed by the same kinds of socio-economic and ecological conditions.

Are there any patterns that are generalizable across cases of conflict?

None of the situational factors on its own could be used to predict how farmers perceive jaguars and deal with depredation. There was only one weak but consistent pattern across all case studies: tolerance of jaguars and attitudes towards jaguars were most likely to be predicted to some extent by a factor of how many livestock a farmer loses to jaguars, combined with how he perceives the social norms of his community.

Are there any insights about tolerance or attitudes that can aid mitigation efforts?

With such a paucity of predictability in conflict situations, mitigation efforts should focus on the process of working with farmers, learning about the communities with which we are dealing, how to interpret any underlying issues and how to accept the unpredictability of each scenario, knowing the right questions to ask and to think more creatively than logically about possible solutions.

Is it possible to scale-up context-dependent insights?

We conclude that observations of patterns in human-wildlife conflict scenarios are valid only for informing action at a local scale, not for generalisation. However, in most cases, strategies focussing on reducing mortalities of livestock combined with social marketing (a method to influence values and behaviours) to improve attitudes towards jaguars may be the broad way forward for human-jaguar conflict resolution. Although each case is likely to require individual treatment, insights from wide-ranging studies can provide familiarity with the range of possible scenarios, adding breadth of information to depth of local experience.

4) Why some conflicts are easier to resolve than others

Why does reducing depredation not necessarily resolve a given conflict?

Tolerance is often not linked to losses. The perception that jaguars are responsible for income losses can be sufficient to trigger retaliatory killing, regardless of the real extent of the damage. The visible dispute over livestock losses may be obscuring deeper frictions about indirectly related issues. Efforts to address only the economic loss without considering the underlying socio-political conflicts affecting the situation may result in only temporary fixes, or even exacerbate the conflict.

How can we conceptualise human behaviour to resolve conflict more effectively?

Our conceptual model explains the between perception and reality in human-wildlife conflicts and distinguishes between three levels of conflict: dispute, underlying, and deep-rooted. Dispute-level conflicts can be settled with practical interventions, while underlying conflicts need to address an unresolved history of grievances, and deep-rooted conflicts have to reconcile different values and beliefs. Once identified, approaches for mitigating these situations must be appropriate for the level conflict involved.

How can we rapidly identify the level of conflict in a given situation?

There are certain signs or indicators which help identify the level of conflict for a given scenario. To uncover underlying or deep-rooted conflict, questions should focus on exploring the farmers' values, the history of the problem, relationships with third parties, perceptions about relevant authorities, and any other socio-political issues that may be concerning them. For example, at the dispute level, a farmer would in conversation be interested in suggestions of practical assistance, while at the deep-rooted level, he would talk more about who is to blame and seem disproportionately irritated about the issue.

Which scenarios tend to involve the most complex conflicts?

There is some tendency for those who show signs of deep-rooted conflict to be those who use a larger proportion of their land for livestock, have lower tolerance of jaguars, and worry about depredation more. They also tend to be the educated, larger landowners with larger herds of livestock (i.e. ranchers rather than smallholders) in communities where the social norms about jaguar persecution are negative. However, any 'type' of farmer or community could harbour deep-rooted issues, so it is important to identify the level of conflict before deciding on a course of action.

What are the appropriate approaches for the different levels of conflict?

Disputes, which are about negotiable interests, can be approached through negotiation, resulting in settlements acceptable to all parties involved, which may involve improving livestock husbandry practices and productivity to off-set the risk of depredation. In an underlying conflict situation, grievances need to be addressed. Practical solutions are still relevant and useful, but these need to be combined with approaches that address behaviour change, such as social marketing. Addressing a deep-rooted conflict is the most challenging as it impacts the identity of the parties involved. This level of conflict cannot be negotiated and instead involves a process of reconciling opposing beliefs and values.

Final summary

Conservation strategies for wide-ranging species require efforts at range-wide, regional and local levels simultaneously. The jaguar will have to survive outside protected areas in many parts of its range, and this will only be possible in the long-term if we become very good at preventing emerging and mitigating existing human-wildlife conflicts.

There are three courses of action needed to manage and prevent conflicts across the jaguar range: a) protection of wild prey, b) improvements to livestock practices, and c) influencing farmers' behaviours. A shift is needed from studies that assess conflicts to initiatives that implement these actions on the ground. The future of jaguars is overwhelmingly dependent on farmers and their behaviours. While there have not yet been many studies explaining the psychology of human-jaguar conflicts, there are many in related fields from which we can borrow an understanding of the key concepts of social approaches in conservation.

With most of the jaguar range outside of protected areas, reliance on these will not be enough for the species to survive in the long term. The Jaguar Corridor strategy has excellent potential for ensuring the safe and conflict-free connectivity of jaguar

populations, but will need to be monitored carefully for any emerging conflicts, otherwise these could begin to show edge effects as seen near protected areas, and become population sinks to the JCU core areas that they are intended to connect.

Each case of conflict is unique. In each there are different stakeholders, values, identities, histories, socio-political factors and opportunities. In most scenarios the general recommendation to focus efforts on improving livestock-based livelihoods and influencing behaviours and social norms is likely to be a step in the right direction. However, treating conflicts simply by improving husbandry will not result in significant change in cases where the reasons for the conflict are deeper than simple complaints about jaguars. Underlying and deep-rooted conflicts are the reason why tolerance of jaguars is often not linked to actual losses of livestock. Ultimately, conflicts can only be resolved if the level of conflict is understood and addressed in the appropriate way. Therefore, the only way to improve our rate of success in managing human-wildlife conflicts is to become better at understanding the how behaviours are shaped and how to devise the right approaches to influence these.

A thorough overview of the kinds of scenarios and solutions that exist in other regions is helpful for developing local strategies. On the ground, however, this theoretical insight serves mainly as a supporting framework to the experience, relationships and intuition that a local expert can bring to working with the affected people in each specific case.

APPENDIX 1:

Questionnaire Survey

Expert-based survey of human-jaguar conflicts

A RANGE-WIDE SURVEY OF JAGUAR-HUMAN CONFLICTS

Survey by A. Zimmermann, Wildlife Conservation Research Unit, Oxford University

Please return survey by email to alexandra.zimmermann@zoo.ox.ac.uk or fax to +44 1865 393101

This survey is also available to fill out online at http://www.surveymonkey.com/s.aspx?sm=VAXQ600dYGi8LFLxP2RSCA_3d_3d

Thinking about one community familiar to you that lives near areas where jaguars exist:

(“Community” in the sense of a group of people resident in an area, sharing ethnic or cultural characteristics, for example Mayan villages on the edge of a park, or the cattle ranchers of a certain region)

1. What is the name of the community (or how would you describe it)?

2. Where is this community?

a) Country:

b) Location (region or area, as precise as possible):

3. Does this community experience any losses of livestock, pets or attacks on people, which it blames on jaguars or other carnivores?

yes no

If yes, which species are blamed for these losses:

	<i>entirely</i>	<i>mostly</i>	<i>some</i>	<i>none</i>
Jaguar				
Puma				
Other				

4. Cultural background: the people of this community group are mostly:

- long-resident, multi-generational cattle ranchers
- recent or new settlers from other areas
- indigenous peoples
- managers of a company, or corporation-owned farm
- other: (please describe) _____

5. Land tenure: what ownership of the land do the people of this community have?

- owners living on their land/farm
- absentee owners
- long-term lease
- indigenous land rights
- new or migrant settlements
- illegal settlements
- other: (please describe) _____

6. Land-use: the land on which the community lives is used mainly for:

- large-scale professional or traditional livestock ranching (e.g. ranches often around 10,000 ha or larger)
- medium-sized cattle/livestock ranching (ranches under 1,000 ha)
- small-scale or subsistence livestock keeping/herding (permanent or migratory, under 100 ha)
- small-scale or subsistence agricultural land, with occasional livestock kept
- commercial agricultural land, no livestock
- land used for other purposes, please describe: _____

7. Income sources: this community lives on income derived from:

<i>Income source</i>	<i>entirely</i>	<i>mostly</i>	<i>partly</i>	<i>none</i>
livestock				
agriculture				
crafts				
tourism				
labour				
other industries				

8. Which animals are a) kept by this community, and b) taken by jaguars? (*tick those that apply*)

	<i>a) animals kept</i>	<i>b) losses blamed on jaguars</i>
cows		
horses		
donkeys		
buffalos		
camelids		
dogs		
sheep		
goats		
pigs		
poultry		
other		

9. Livestock husbandry: how does this community manage the livestock it has?

- extensive (free-range, livestock mostly left to roam large fields/paddocks with little guarding)
- intensive (on small areas, heavy use of land, usually fenced in)
- subsistence livestock keeping/herding only (often kept near the house)
- other (please describe):

10. To your knowledge, how frequent are the depredations on livestock or pets by jaguars?

- frequent (many times each year)
- occasional (once or twice a year)
- rare (less than once a year)
- none (no predations by jaguars)
- don't know

11. Do people in this community believe that jaguars sometimes attack people?

- yes no don't know

12. Does this community hunt or persecute jaguars?

- yes probably unlikely no don't know

Is any of this linked to sale or trade in jaguar parts (e.g. fur)? _____

13. Conflict severity: in your impression, how serious or severe is this conflict:

a) for *jaguars*?

- very serious (a major problem for the conservation of jaguars in this region)
- moderately serious (a concern for jaguar conservation, but there are other more serious problems)
- not very serious (not really affecting the survival of jaguar population in this region)

b) for *people*?

- very serious (their economic or subsistence losses are unsustainable)
- moderately serious (a concern for this community, but there are other more serious problems)
- not very serious (jaguar predation of livestock is a rare or minor)

14. In the area you are describing, are there any responses to jaguar depredation by NGOs, government agencies or other bodies?

- local authorities or NGOs respond in cases of “problem animals”
- NGO or other agency involves, to some degree, this community in education, environmental, agronomic or other projects relevant to jaguar conservation
- the community receives no assistance from NGOs or local agencies/authorities

15. Tolerance: what is your impression of the level of tolerance these people have for jaguars

- high tolerance (they accept some losses of livestock, without retaliation)
- medium tolerance (accept value of jaguars in the environment but unhappy about economic losses)
- low tolerance (do not want to co-exist with jaguars at all)

16. Protected area: this community is located:

- inside a protected area or indigenous reserve
- on the border/ just outside of a protected area or indigenous reserve
- not near any protected areas or indigenous reserves
- in a patchy mosaic of protected and non-protected areas

If applicable, please name the protected area: _____

17. Prey base: how is the availability of natural prey for jaguars in this region - is it abundant or overhunted, is it patchily distributed? Please describe:

Your response to the above is based on:

- scientific evidence / data
- your own informal observations
- the observations of others, which you have heard about

18. Habitat: what is the state of the jaguar habitat in this region - how is the quality, what is the level of disturbance or alteration? Please describe:

Your response to the above is based on:

- scientific evidence / data
- your own informal observations
- the observations of others, which you have heard about

19. Do you know about any other communities (different from the one you have described here) that experience conflicts with jaguars?

- yes no If yes, please list them here:

Would you be willing to fill in another copy of this survey for any of those communities?

- yes, fill in another survey now
- yes, but not now
- no

20. Can you suggest any other people who are knowledgeable about cases human-jaguar conflicts, who might be willing to help with this survey?

- END OF SURVEY -

APPENDIX 2:

Questionnaire Survey

Case studies: Survey of farmers

Jaguar Conflict Case Studies

FARMER QUESTIONNAIRE

Community Name & Location:

Background

1) On this farm/property, what is your role?

- owner/co-owner manager/person in charge employee other

2) How long have you lived in this area ?

- since childhood > 20 years 10-20 years 5-10 years <5 years

3) Is your family originally from this community? _____

4) Which of these backgrounds best describes you?

- I come from a farming background (e.g. my father was a farmer)
 I grew up in the countryside but not on a farm
 I grew up in a town or city

5) In which year were you born? 19_____

6) What kind of schooling or study have you had?

- primary school
 high school
 college/university
 apprenticeship/job training
 other

7) Have you ever travelled outside this state/province?

- no, never yes, once or twice yes, a few times yes, often

Land Use

8) What is the size of this farm/property? _____ hectares (or specify unit)

9) Could you describe how the land on this farm is used, in proportions (e.g. %, or area sizes)

- _____ for livestock
- _____ for agriculture
- _____ for timber or non-timber forest products
- _____ for mineral resources (e.g. mining, oil)
- _____ not used / left wild, but not under protected status
- _____ under protected status (e.g. conservation area or indigenous reserve)
- _____ other

10) What type of cattle management style is used on this farm/property?

- extensive (free-range, livestock mostly left to roam large fields/paddocks with little guarding)
- intensive (smaller areas, heavily managed use of land, livestock usually fenced)
- subsistence (for own use only, often kept near the house)
- other (please describe):

Depredation

11) Please provide an idea how many domestic animals there are on this farm, and how many mortalities there are (in total and caused by jaguars). If the numbers vary each year, write the estimated minimum and maximum numbers per year. Cross out those animals which you do not have.

Livestock	Number of stock (per year)		Mortalities in total, all causes (per year)		Number of stock killed by jaguar (per year)	
	min.	max.	min.	max.	min.	max.
Cattle						
Horses						
Donkeys						
Buffalo						
Sheep						
Pigs						
Goats						
Poultry						
Other						

12) Do you also have any problems with pumas? yes no

If yes, which cat is the more of a worry for you? jaguar puma equal d.k.

13) Can you tell if an animal was killed by a jaguar ? yes no sometimes

If yes/sometimes – what clues do you look for? _____

14) Have you noticed any patterns of attacks by jaguars, in terms of time, season and locations?

a) time of day/night: _____; or no pattern

b) season of year: _____; or no pattern

c) locations on the property: _____; or no pattern

15) In recent years, has the amount of time you have had to spend dealing with this issue increased stayed about the same decreased don't know

16) Which best describes your past experience with jaguars taking your livestock?

jaguars have been a problem for me for many years

jaguars have been a problem occasionally

jaguars have only rarely been a problem

jaguars are a very recent / new problem for me

other: _____

17) How serious/worrying is the threat of livestock depredation from jaguars for you?

very serious moderately serious not very serious no problem don't know

18) What other problems (other than jaguars/pumas) cause losses of livestock on your farm? _____

19) What is the biggest challenge or worry for your farm and income?

20) If you keep dogs at your property, have they ever been attacked by a jaguar?

yes no don't have dogs

Do you agree or disagree with each of these statements?

21) It is possible for both people and jaguars to live in this area

agree maybe disagree

22) I am willing to make changes to how I keep my livestock

agree maybe disagree

23) Jaguars threaten my way of life

agree maybe disagree

24) Losing some livestock to jaguars is just a fact of life that I have to accept

agree maybe disagree

Jaguars

25) What three words would you use to describe jaguars?

26) Which of the below experiences with jaguars have you had?

- | | | |
|---|------------------------------|-----------------------------|
| I have seen a jaguar | <input type="checkbox"/> yes | <input type="checkbox"/> no |
| I have heard a jaguar, or seen its signs | <input type="checkbox"/> yes | <input type="checkbox"/> no |
| I have been threatened/attacked by a jaguar | <input type="checkbox"/> yes | <input type="checkbox"/> no |
| My livestock has been attacked by a jaguar | <input type="checkbox"/> yes | <input type="checkbox"/> no |
| My pet(s) have/has been attacked by a jaguar | <input type="checkbox"/> yes | <input type="checkbox"/> no |
| <input type="checkbox"/> no experiences | | |
| <input type="checkbox"/> other experiences: _____ | | |

27) How often do people in your community talk about jaguars attacking people?

- never rarely sometimes often

28) What happens here when a jaguar appears on someone's land?

- it is chased away
 it is shot/killed
 a trap will be set to catch it
 the authorities are called
 people just stay inside until it has gone
 nothing is done
 other (please describe): _____

29) What would you neighbours expect you to do, if a jaguar came onto your land?

30) Do people ever kill jaguars around here?

- yes, often yes, sometimes yes, rarely maybe no I don't know

31) If yes, what would be their reason for hunting or killing a jaguar?

- in *response to* past attacks on livestock
 to *prevent* future attacks on livestock
 to protect human safety
 for cultural reasons or for trophies
 for income
 other reason / don't know

32) Which of the following outcomes would you prefer for jaguars in the future?

- no jaguars anywhere (species extinct)
- no jaguars here, but existing in other places
- fewer jaguars here
- same number of jaguars as there are now
- more jaguars here
- no opinion / don't care

Economics

33) How much do you rely on income from livestock animals?

- totally (more than 90%)
- mostly (about 75%)
- half (about 50%)
- some (about 25%)
- little (less than 10%)

34) Does this farm currently have any actual other income sources? yes no

If yes, what type? _____.

35) If not, do you have any possibilities for other or additional sources income sources that you could pursue in future? yes no uncertain

36) If it would prevent the jaguar's extinction, would you be willing to tolerate any losses of your livestock to jaguars? yes no uncertain

Mediation

37) How important to you is it to protect your livestock from jaguars?

- very important
- somewhat important
- not important
- don't know

38) Have you tried any methods for preventing jaguar attacks on livestock? If yes, please describe:

Method

How well does it work?

39) Are there any methods you have heard about elsewhere, but not tried yourself? If yes, please describe:

40) Is there currently (or has there been in the past) any help available from organisations or government for managing predation on your livestock by jaguars?

- yes, there is currently
- yes, there was in the past (but not now)
- no, there has never been
- don't know

41) If yes (currently or in the past), what kind of help was this?

42) If yes (currently or in the past), did you make use of this? yes no

43) What kind of assistance would you most like to receive?

44) Whose responsibility is it to deal with jaguar/livestock problems?

- the farmer himself the local authorities both, but more the farmer's
 both, but more the authorities' neither don't know

Conservation

45) Jaguars need wild areas. Do you think the jaguar's *natural habitat* in this area, in the past 5 years has: increased not changed decreased don't know

46) Jaguars need wild animals to hunt/eat. Do you think the numbers of *wild prey* in this area, in the past 5 years have: increased not changed
 decreased don't know

47) Do you think in this region the *number of jaguars* in the past 5 years has:

- increased not changed decreased don't know

48) Are there any reserves or national parks around here?

- yes no don't know

49) If yes, do you benefit from this in any way? _____

Do you agree or disagree with each of these statements?

50) Having protected areas (like national parks) for jaguars and other wildlife is a good thing agree maybe disagree

51) The protection of jaguars is a waste of effort and money agree maybe disagree

52) I do not trust conservation people agree maybe disagree

53) My values are different from those of conservation people agree maybe disagree

54) The government cares too much about jaguars and not enough about other problems farmers have in this area agree maybe disagree

Appendix 3:

Human-Felid Conflict: A Review of Patterns & Priorities Worldwide

Inskip, C. & Zimmermann, A. (2009). Human-Felid Conflict: A Review of Patterns & Priorities Worldwide. *Oryx* 43 (1): 1-17

Review

Human-felid conflict: a review of patterns and priorities worldwide

CHLOE INSKIP and ALEXANDRA ZIMMERMANN

Abstract Conflict between people and felids is one of the most urgent wild cat conservation issues worldwide, yet efforts to synthesize knowledge about these conflicts have been few. For management strategies to be effective a thorough understanding of the dynamics of human-felid conflicts is necessary. Here we present the results of a cross-species, systematic review of human-felid conflicts worldwide. Using a combination of literature review and geographical information system analyses, we provide a quantitative as well as qualitative assessment of patterns and determinants that are known to influence the severity of human-felid conflicts, and a geographical overview of the occurrence of conflict worldwide. We found evidence of conflict affecting over 75% of the world's felid species. The severity of conflict increases with felid body mass and is of greatest conservation significance to nine species: caracal, cheetah, Eurasian lynx, jaguar, leopard, lion, puma, snow leopard and tiger. We also reveal specific gaps in knowledge about human-felid conflicts, and required actions within this aspect of felid conservation. With only 31% of implemented management strategies having been evaluated scientifically, there is a need for greater and more rigorous evaluation and a wider dissemination of results. Also urgently required are standardized reporting techniques to reduce the current disparity in conflict reporting methods and facilitate resolution of patterns and trends in the scale of human-felid conflict worldwide. This review provides a basis both for further synthesis and for the coordination of human-felid conflict management among researchers, practitioners and organizations.

Keywords Conflict mitigation, felid, human-felid conflict, human-wildlife conflict, livestock depredation, persecution, wild cats.

This article contains supplementary material that can be found online at <http://journals.cambridge.org>

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Received 26 February 2008. Revision requested 16 May 2008.
Accepted 4 July 2008.

Introduction

The increasing human population and the associated increase in rates of resource use and habitat loss worldwide are, in many areas, forcing wildlife to live in increasing proximity to humans. In such circumstances competition arises between wildlife and people for space and food resources, often leading to human-wildlife conflict. Definitions of the term vary (c.f. Conover, 2002; IUCN, 2003; Madden, 2004). We define human-wildlife conflict as the situation that arises when behaviour of a non-pest, wild animal species poses a direct and recurring threat to the livelihood or safety of a person or a community and, in response, persecution of the species ensues. Human-wildlife conflicts most commonly involve damage to crops or killing of livestock or game, and occasionally involve attacks on people. They are of particular concern when the animal persecuted in retaliation for these events is a threatened species.

Carnivores are particularly predisposed to conflict with humans because of their large home ranges and dietary requirements (Linnell et al., 2001; Macdonald & Sillero-Zubiri, 2002). Human-carnivore conflict appears to be increasing in frequency in many areas (Treves & Karanth, 2003), presenting a significant threat to many carnivore species, including many threatened species of wild felids. Human-felid conflict typically occurs when wild cats prey on livestock or game, or even attack people, and the people affected respond by killing or harming felids, either in retaliation or as a preventative measure.

Effective human-felid conflict management is essential given the precarious conservation status of many felid species, yet also highly complex as it must reconcile human needs with those of felid populations. Despite the urgency and importance of resolving these conflicts, there does not yet appear to have been a review of such conflict on a global scale or the success of management techniques worldwide. Our aim was therefore to provide a systematic, cross-taxonomic, review of the state of knowledge and practice of human-felid conflict globally. Specifically, our research questions were: (1) Which cat species are affected by conflict and to what extent? (2) What are the spatial, taxonomic and socio-economic patterns of these conflicts? (3) What are the factors that determine the scale of conflict? (4) What is the scope of the available human-felid conflict literature and what information needs are apparent? (5) To what

extent have conflict management strategies been implemented and evaluated?

Methods

Sourcing information and data collation

A comprehensive and systematic review of scientific, secondary and internet-based literature on human-felid conflict was carried out. Information regarding such conflict was sought for the 37 extant felid species (Nowell & Jackson, 1996, with the addition of the more recently described Bornean clouded leopard *Neofelis diardi*; Kitchener et al., 2006).

A literature search was carried out using a pre-defined search protocol, involving a number of filters based around a set of keywords, selected to balance search sensitivity (finding all relevant information) with specificity (the proportion of hits returned that are relevant; Pullin & Stewart, 2006). All of the keywords used in our searches were English. Although this will have precluded a number of non-English language literature sources from our review this restriction was necessary to limit the sources obtained to a manageable number. To be selected, a literature source had to include a felid name (common or scientific), and one or more of the following keywords: attacks, attitudes, cattle husbandry or management, coexistence, conflict, depredation, diet, ecology, feeding ecology, human, livestock, mitigation, mortality, perceptions, persecution, prey, retaliatory killing. Scientific literature was sourced from scientific databases such as ISI Web of Science (2007), the IUCN/SSC Cat Specialist Group (2007), and Google Scholar (Google, 2007b), and searches for secondary and internet-based literature were carried out using web-based search engines. A 'snowball' reference technique was then used, which resulted in the opportunistic inclusion of some non-English literature. In some cases, particularly for the smaller felid species, no (or no relevant) scientific or secondary literature was available; so information from the most reliable internet sources available was used or expert opinions sought.

Felid body mass data were obtained from Nowell & Jackson (1996), Macdonald (2006), Hutchins et al. (2003) and the Cat Survival Trust (2007). The average weight for each species was calculated from the minimum and maximum mean weight provided by at least two of these sources. Species were categorized by (1) body mass (≤ 10 kg, 11–49 kg, ≥ 50 kg), (2) the extent of information available, and (3) the scale of conflict (see Table 1 for definitions of the categories used).

Where the data allowed, the average annual attack or persecution rate was calculated. Time scales of reports were calculated from the beginning of the first year to the end of the last year documented, unless the article specified

otherwise. For example, a report between 2000 and 2002 was calculated as a time period of 3 years. Statistical analyses were carried out using SPSS v. 9 (SPSS, Chicago, USA).

Details of all conflict management techniques mentioned in the literature reviewed were recorded and coded by whether they were implemented or proposed techniques, by whether they had or had not been evaluated scientifically (see Table 1 for definition), and by the felid species involved. The location of each implemented technique was recorded and any anecdotal evidence of a technique's success rate was noted. The implemented conflict management techniques were then categorized by type into 12 groups: financial, livestock husbandry, livestock guarding, education and community development, deterrents, barriers, aversive conditioning, translocation, lethal control, zoning, land use, and attack verification.

Mapping conflict locations

Maps of felid species' ranges were sourced (Appendix 1). Some were available in the required geographical information system (GIS) format, others were converted to JPEG images, imported into the geographical system *ArcView* v. 9.2 (ESRI, Redlands, USA), georeferenced and digitized to provide species range layers. Where possible, coordinates for conflict presence/absence were obtained from the literature, or acquired from *ArcView* (using the World Database on Protected Areas, see Appendix 1), Google Earth (Google, 2007a) or Wikipedia (2007). The coordinates obtained varied in accuracy depending on the geographical scale of the report and the resolution of the resource used. Where the coordinates provided by a reference demarked an area, for example a national park, the central point coordinates were calculated. Coordinates were standardized by converting them to decimal degrees using a coordinate converter (COSports, 2007). GIS-compatible global livestock density data were obtained, as was the World Database on Protected Areas (sources detailed in Appendix 1).

Results

Literature quantity and quality

In total 349 literature sources (189 scientific articles, 74 secondary and 86 web pages) were reviewed. The primary and secondary literature was published over 1979–2007, and the number of sources per publication year increased significantly over this period (Spearman's Rank Correlation, $r_s = 0.763$, $P < 0.001$; Fig. 1). The conflict literature was biased toward large-bodied species (Spearman's Rank Correlation, $r_s = 0.536$, $P = 0.001$): 67% of sources contained information about large (≥ 50 kg) felid species (Fig. 2) and

TABLE 1 Definitions of the categories used to sort the data collated from the literature review.

Category	Definition
Extent of knowledge	
Conflict well documented (CWD)	Conflict between people & felid species documented in > 5 primary literature sources and detailed information available from secondary literature & websites
Conflict poorly documented (CPD)	Evidence in < 5 primary literature sources that a species is involved in conflict & only general information available from secondary literature (if at all) or from websites. More research needed to clarify the extent of conflict.
No conflict (NC)	Evidence in literature that the species is not involved in conflict in a particular location (this includes studies that directly confirm conflict does not occur at a location and reports that indirectly imply there is no conflict; for example, when no livestock remains have been found in a felid species' scats at that location)
Expert opinion (EX)	Categorization based on expert opinion due to paucity of information in the literature (primary, secondary or internet); in some cases therefore, research is required to clarify whether a species is or is not involved in conflict
Research required (RES)	A paucity of information in the literature & no species expert identified, therefore research is required to clarify whether species is involved in conflict &, if so, the extent of the problem. For many species there is a need for more general research to improve our knowledge of behaviour & ecology.
Scale of conflict	
Severe	High frequency of (perceived) livestock depredation, attacks on people, retaliatory killing
High	High frequency of (perceived) livestock depredation, low frequency of attacks on people (if any), high levels of retaliatory killing
Moderate	Some livestock depredation, no attacks on people, retaliatory killing frequent
Low	Infrequent livestock depredation, no risk to humans, some retaliatory killing
None	No evidence of species exhibiting conflict behaviours or being a perceived threat to humans or livestock, or of retaliatory killing
Data deficient	Very little reliable (especially scientific) information available regarding the species
Applied and evaluated mitigation	
Evaluated	Mitigation strategy scientifically evaluated and results reported in primary literature. Success may be conditional, i.e. a strategy may only work in certain conditions.
Not evaluated	No scientifically-based evaluation of strategy. There may, however, be an indication of success and failure in the literature.

conflict, or a lack thereof, was therefore better documented for these species (Fig. 3 & Table 2).

Felid conflict species

Felid species were assigned to conflict categories based on the evidence in the literature reviewed (Fig. 4 & Table 2): there was no evidence of conflict for seven species, evidence of a low level of conflict for 20 species, and evidence of a moderate or higher level of conflict for nine species. We

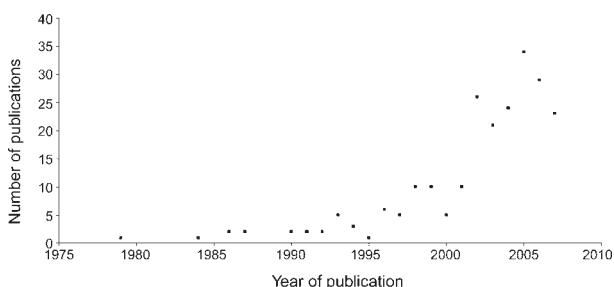


FIG. 1 Publication dates of primary and secondary literature sources reviewed.

categorized the Bornean bay cat *Catopuma badia* as data deficient because of insufficient information (Table 1). The severity of conflict differed significantly between felid weight groups (Kruskal Wallis, $\chi^2 = 21.021$, $P < 0.001$). Conflict is more severe with large cats than with either medium (Mann-Whitney U , $Z = -3.268$, $P = 0.001$) or small cats

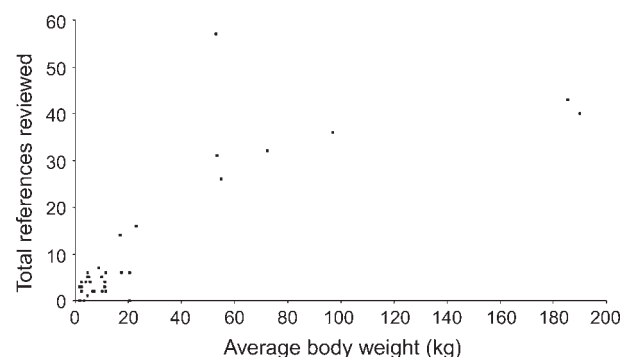


FIG. 2 Total number of information sources (white and grey literature and website resources) reviewed for each of the 39 felid species; 67% of literature sources reviewed concerned species with an average body mass ≥ 50 kg.

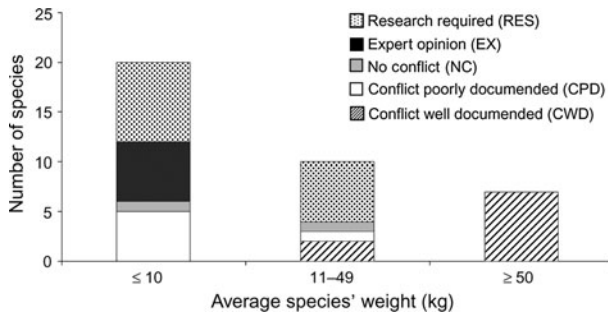


Fig. 3 Extent of felid conflict knowledge determined by the number and type of literature sources accessible for each species. See Table 1 for full category definitions.

(Mann-Whitney U , $Z = -4.143$, $P < 0.001$), and conflict with medium and small cats is of a similar intensity (Mann-Whitney U , $Z = -1.894$, $P = 0.126$). With the exception of the caracal *Caracal caracal* (17 kg) and Eurasian lynx *Lynx lynx* (23 kg) all of the species with which conflict is of a moderate or higher level have an average body mass > 50 kg. For the remainder of the analyses and synthesis we focus on the nine species for which conflict is of a moderate or higher level: caracal, cheetah *Acinonyx jubatus*, Eurasian lynx, jaguar *Panthera onca*, leopard *Panthera pardus*, lion *Panthera leo*, puma *Puma concolor*, snow leopard *Uncia uncia* and tiger *Panthera tigris*.

Scale of conflict

Livestock depredation Both livestock depredation and attacks on people may incite human-felid conflict but, of the two, livestock depredation occurs more frequently, with cattle, sheep and goats being most commonly attacked (Table 3). Although well documented, livestock depredation data in the literature are quantified in incomparable ways, for example: the total number of livestock lost, the percentage of livestock holdings lost, the quantity of livestock remains in felid scats, or the percentage of the total number of livestock lost to all predators. Of the total primary and secondary literature sources, 225 concerned the nine conflict felids and of these only 10% contained information on the economic loss resulting from livestock depredation. The data are reported in different currencies as absolute values, percentages of income, or percentage of all monetary loss to predators or wildlife (Appendix 2) making them incomparable. No data were available on the economic loss resulting from depredation by caracals or cheetahs. Appendix 2 summarizes the livestock depredation and economic data available in the literature.

Attacks on people Of the nine conflict felids only those with an average body mass > 50 kg show a propensity to attack humans. The three species responsible for most attacks are

leopard, lion and tiger; attacks by puma and jaguar are comparatively rare (Beier, 1991; Perovic & Herrán, 1998; Quigley & Herrero, 2005; Altrichter, 2006), and there are no reports of snow leopards or cheetahs attacking humans. Calculation of an average annual attack rate was possible for most locations and indicated that attack rates are not evenly distributed across species' ranges (Appendix 3). The differing geographical scales of reports make further comparisons difficult but reports suggest that attacks have generally declined over time (Thirgood et al., 2005), a trend possibly linked with declining felid populations (Nowell & Jackson, 1996; Treves & Naughton Treves, 1999). However, in some Asian and African locations attacks are still common (Thirgood et al., 2005). For example, attacks by lions increased significantly in Tanzania over 1990–2005 (Packer et al., 2005). An increase in attacks by pumas has also been reported in the USA and Canada in recent decades (Beier, 1991).

Retaliation against felids Appendix 4 summarizes the reports of the numbers of felids killed in retaliation for livestock depredation and/or attacks on humans. Generally, the data presented in the literature allowed the calculation of the average annual persecution rate for each location but, as with the data for attacks on humans, reports are at differing spatial scales. The extent of retaliation was quantified in various ways, including as a percentage of felid mortality. For example, 47% of cheetah (Marker et al., 2003a), 46% of Eurasian lynx (Andrén et al., 2006), and up to 50% of tiger (Miquelle et al., 2005) mortality has been attributed to retaliatory killing in certain regions. Responses from surveys indicate that 39% of respondents in Belize have hunted cats in retaliation for livestock depredation (Brechtin, 2003), 88% of ranchers interviewed in the Brazilian Pantanal believe that jaguars are shot by ranchers to prevent cattle losses (Zimmermann et al., 2005), and 14% of herders interviewed in four Mongolian regions have hunted snow leopards (Allen et al., 2002).

Geographical distribution of conflict Locations at which the presence ($n = 176$) or absence ($n = 9$) of conflict with at least one felid species has been reported were identified from the literature and mapped. They are presented for each felid species (Fig. 5) and globally (Fig. 6). Fig. 6 highlights a degree of clustering in the location of research efforts and also provides an illustration of the distribution of felid species and conflict in relation to livestock density and the number and distribution of protected areas.

Determinants of conflict

A multitude of factors influence the occurrence and scale of conflict. Because of the extent and complexity of these factors a comprehensive review is beyond the scope of this article, although we present the key findings and conclusions from the literature reviewed.

TABLE 2 Felid conflict categories, average body mass, extent of conflict knowledge, and threat status.

Species	Conflict category	Extent of knowledge ¹	Average body mass (kg) ²	Red List status ³
Bornean bay cat <i>Catopuma badia</i>	DD	RES	3.5	EN
Sand cat <i>Felis margarita</i>	No conflict	EX	2.4	NT (<i>F. m. scheffeli</i> , LR/nt)
Black-footed cat <i>Felis nigripes</i>	No conflict	EX	1.78	VU
Canadian lynx <i>Lynx canadensis</i>	No conflict	NC	11.5	LC
Chinese mountain cat <i>Felis bieti</i>	No conflict	EX	7.25	VU
Flat-headed cat <i>Prionailurus planiceps</i>	No conflict	EX	4.75	VU
Iberian lynx <i>Lynx pardinus</i>	No conflict	NC	9	CR
Manul/Pallas's cat <i>Otocolobus manul</i>	No conflict	EX	3.5	NT (<i>O. m. ferrugineus</i> , LR/nt)
African golden cat <i>Profelis aurata</i>	Low	RES	11.65	VU
Andean mountain cat <i>Oreailurus jacobitus</i>	Low	CPD	5.25	EN
Asiatic golden cat <i>Catopuma temmincki</i>	Low	RES	11	VU
Bobcat <i>Lynx rufus</i>	Low	CPD	17.5	LC
Clouded leopard <i>Neofelis nebulosa</i>	Low	RES	20.5	VU
Bornean clouded leopard <i>Neofelis diardi</i> ⁴	Low	RES	20.5	Not yet classified
Fishing cat <i>Prionailurus vierrinus</i>	Low	RES	10.25	VU
Geoffroy's cat <i>Oncifelis geoffroyi</i>	Low	RES	4	NT
Jaguarundi <i>Herpailurus yagouaroundi</i>	Low	RES	6.5	LC (<i>H. y. cacomitli</i> , EN)
Jungle cat <i>Felis chaus</i>	Low	CPD	10	LC
Kodkod/guigna <i>Oncifelis guigna</i>	Low	CPD	2.5	VU
Leopard cat <i>Prionailurus bengalensis</i>	Low	RES	4.75	LC (<i>P. b. iriomotensis</i> , EN)
Marbled cat <i>Pardofelis marmorata</i>	Low	RES	4	VU
Oncilla <i>Leopardus tigrinus</i>	Low	EX	2.5	NT
Margay <i>Leopardus weidi</i>	Low	RES	5.75	LC
Ocelot <i>Leopardus pardalis</i>	Low	RES	11.5	LC (<i>L. p. albescens</i> , EN)
Pampas cat <i>Oncifelis colocolo</i>	Low	CPD	4.8	NT
Rusty-spotted cat <i>Prionailurus rubiginosus</i>	Low	RES	1.5	VU
Serval <i>Leptailurus serval</i>	Low	RES	11.25	LC (<i>L. s. constantinus</i> , EN)
Wild cat <i>Felis silvestris</i>	Low	CPD	4.5	LC (<i>F. s. grampia</i> , VU)
Caracal <i>Caracal caracal</i>	Moderate	CWD	17	LC
Cheetah <i>Acinonyx jubatus</i>	Moderate	CWD	53.5	VU (<i>A. j. hecki</i> , EN; <i>A. j. venaticus</i> , CR)
Eurasian lynx <i>Lynx lynx</i>	High	CWD	23	NT
Jaguar <i>Panthera onca</i>	High	CWD	97	NT
Puma <i>Puma concolor</i>	High	CWD	72.5	NT (<i>P. c. coyri</i> , <i>P. c. cougar</i> , CR)
Snow leopard <i>Uncia uncia</i>	High	CWD	55	EN
Leopard <i>Panthera pardus</i>	Severe	CWD	53	LC (<i>P. p. ciscaucasia</i> , <i>P. p. japonensis</i> , <i>P. p. jarvisi</i> , <i>P. p. kotiya</i> , <i>P. p. melas</i> , <i>P. p. saxicolor</i> , EN; <i>P. p. nimr</i> , <i>P. p. panthera</i> , <i>P. p. tulliana</i> , CR)
Lion <i>Panthera leo</i>	Severe	CWD	190	VU (<i>P. l. persica</i> , CR)
Tiger <i>Panthera tigris</i>	Severe	CWD	185.5	EN (<i>P. t. altaica</i> , <i>P. t. amoyensis</i> , <i>P. t. sumatrae</i> , CR)

¹RES, research required; EX, expert opinion; NC, no conflict; CPD, conflict poorly documented; CWD, conflict well documented (see Table 1 for full descriptions of categories)

²From Nowell & Jackson (1996), Macdonald (2006), Hutchins et al. (2003), Cat Survival Trust (2007)

³CR, Critically Endangered; EN, Endangered; VU, Vulnerable; LR/nt, Lower Risk/Near Threatened; LC, Least Concern (IUCN, 1994, 2001)

⁴Clouded leopard categorization has been used here as there is no information specifically for Bornean clouded leopard.

Habitat availability Increasing competition for space between humans and felids is the core factor underlying the occurrence of conflict. Habitat degradation is currently one of the greatest threats to the survival of large felid species worldwide (Mazzoli et al., 2002) and certain felids, such as lions, are increasingly restricted to protected areas (Loveridge, 2002). However, few protected areas are of a

size sufficient to host viable large carnivore populations (Breitenmoser et al., 2005). Large carnivores, including large felids, have extensive home-ranges that frequently extend beyond reserve borders into human-dominated areas. Consequently, conflict can become particularly acute in reserve border areas and may result in such areas becoming population sinks (Woodroffe & Ginsberg, 1998).

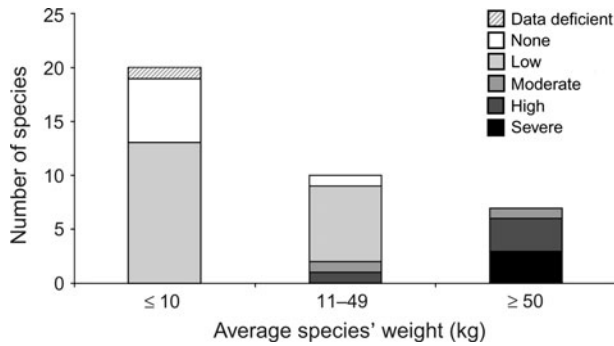


FIG. 4 Scale of human-felid conflict determined by the frequency of livestock depredation, attacks on humans and retaliatory killing of felids reported in the reviewed literature. See Table 1 for full category definitions.

Conflict also affects species such as cheetah and Eurasian lynx that, across all or parts of their ranges, are found predominantly outside protected areas (Marker et al., 2003b; Andr en et al., 2006). In certain locations, for example the Russian Far East, a lack of protected areas is of particular concern for the survival of felids (Miquelle et al., 2005) yet, paradoxically, the establishment of protected areas can increase conflict (Johnson et al., 2005; Wang & Macdonald, 2006).

Wild prey availability Availability of wild prey affects the potential for conflict with each of the conflict felids. Depredation rates tend to be higher in areas where, or at a time of year when, wild prey is less abundant (Saberwal, 1990; Nowell & Jackson, 1996; Pedersen et al., 1999; Polisar et al., 2003; Athreya et al., 2004; Bagchi & Mishra, 2006; Johnson et al., 2006; Melville & Bothma, 2006). However, in Norway and the French Jura, high depredation rates by Eurasian lynx on domestic sheep have been linked with an abundance of wild prey (Stahl et al., 2001a; Herfindal et al., 2005). The frequency of attacks on people by lions and tigers has also been linked with low prey availability (Jackson, 1991; Reza et al., 2002; Packer et al., 2005).

Livestock husbandry and management In many locations poor husbandry and management practices are in part responsible for high levels of livestock depredation (Mishra et al., 2003; Thirgood et al., 2005). Poor guarding or herding practices, the location of grazing pastures, often in close proximity to, or within, felid habitat (Weber & Rabinowitz, 1996; Rao et al., 2002; Herfindal et al., 2005; Rabinowitz, 2005; Kolowski & Holekamp, 2006) and inadequate, or a lack of, pens in which to keep livestock at night (Jackson, 1999; Wang & Macdonald, 2006) are the primary reasons for this.

Human behaviour and activity patterns The majority of attacks on people occur when they venture into felid habitat (Sanyal, 1987; Weiler, 1998; McDougal, 1999; Reza et al., 2002; Mukherjee, 2003) or when they are tending domestic animals or crops (Vijayan & Pati, 2002; Nyhus & Tilson, 2004a). Hunting of felids (Maddox, 2003) and sleeping outside or in makeshift huts during summer months (Vijayan & Pati, 2002; Packer et al., 2005) have been linked with increased risk of attack, and clustering of attacks around Gir Forest, India, has been linked to sites previously used for the baiting of lions for the tourism industry (Saberwal et al., 1990).

Socio-economic determinants A complex, varied and dynamic combination of socio-cultural factors affect the human dimension of human-felid conflict. Attitudes (Athreya et al., 2004; Rabinowitz, 2005; Zimmermann et al., 2005; Ramo n ach et al., 2007), perceptions (Macdonald & Sillero-Zubiri, 2002; Marker et al., 2003b; Madden, 2004), belief systems (Hussain, 2002; Nugraha, 2005), educational and value systems (Shivik et al., 2003), religion (Ale et al., 2007), and the economic importance of livestock to a community (Bagchi & Mishra, 2006) can determine tolerance levels and govern the type and severity of human response to felids. Attitudes and perceptions in particular may distort the scale of conflict (Conforti & Azevezo, 2003; Marker et al., 2003a; Silva-Rodr guez et al., 2007) causing people to take

TABLE 3 Livestock species attacked by the nine species of felid involved in conflict, as reported in the literature.

	Poultry	Dog	Goat	Domestic sika deer	Sheep	Pig	Semi-domestic reindeer	Donkey	Horse	Camel	Cattle ¹	Yak	Buffalo ²
Caracal			X		X								
Cheetah			X		X						X ³		
Eurasian lynx			X		X ³		X						
Jaguar		X				X					X		
Leopard	X	X	X	X	X					X ³	X		
Lion			X		X	X		X		X	X		X
Puma			X		X	X					X ³		
Snow leopard			X		X			X			X	X	
Tiger	X		X	X				X			X	X	X

¹Includes oxen

²Domestic buffalo in India

³Indicates a preference for subadult individuals

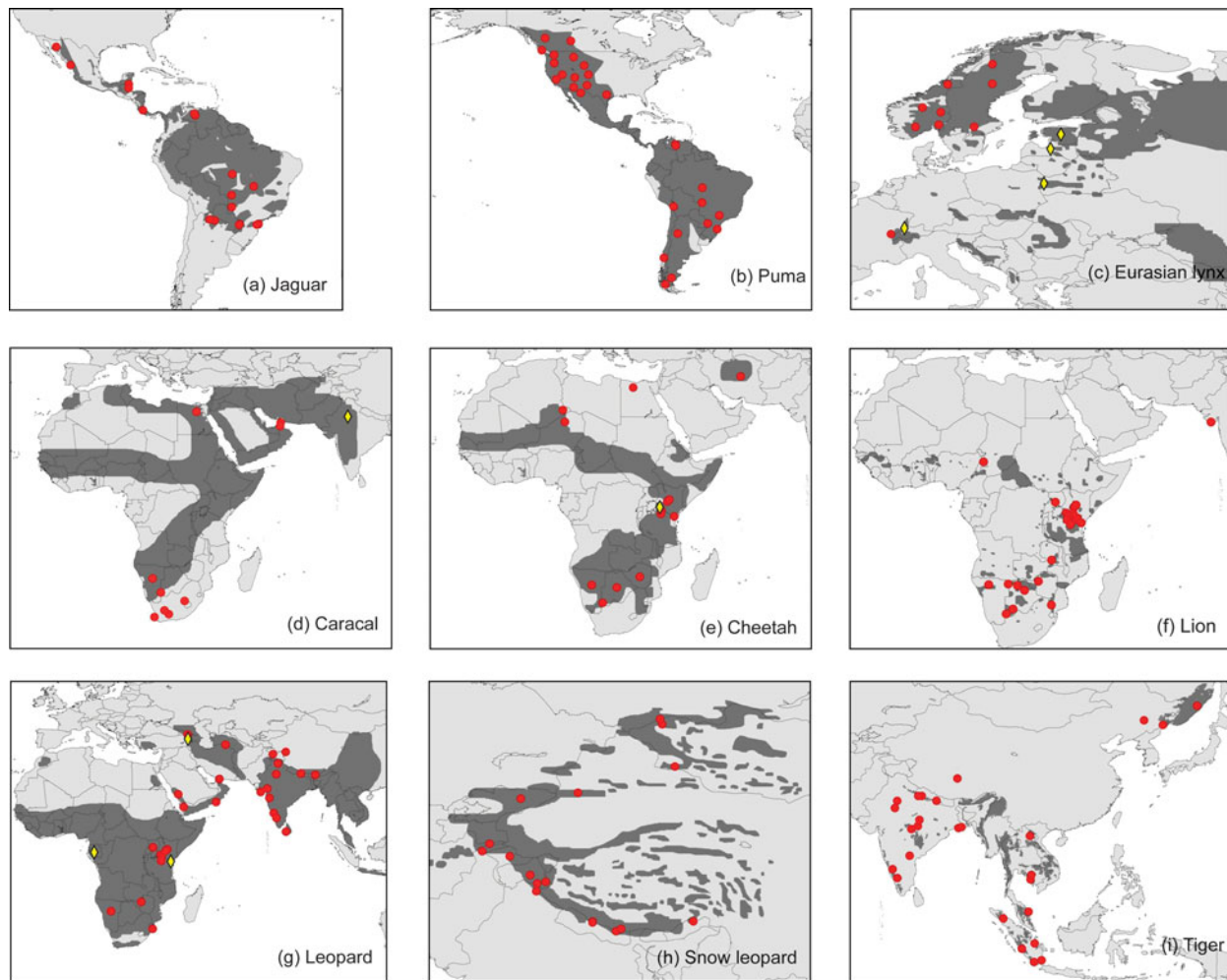


FIG. 5 Locations for which there is evidence of conflict or no conflict in the literature reviewed for each of the nine felid conflict species. Red circles denote conflict locations; yellow diamonds denote locations with no conflict. For details of felid range data sources see Appendix 1.

retributive action that is disproportionate to the actual scale of the problem. Little information is available regarding the human aspect of conflict in many locations but a number of studies (Oli et al., 1994; Saberwal et al., 1994; Weiler, 1998; Sekhar, 1998; Hussain, 2000; Reza et al., 2002; Maddox, 2003; Casey et al., 2005; Rabinowitz, 2005; Altrichter et al., 2006; Silva-Rodríguez et al., 2007) indicate significant geographical variation in attitudes towards felid species and their habitats. Wealth may also in part determine the number of livestock lost and consequently how losses are distributed throughout a community. For example, Saberwal et al. (1994) found that poorer villagers around the Gir Forest, India, lost substantially more livestock to depredation than wealthier villagers who could afford better husbandry and protective measures for their animals.

Spatial determinants Landscape characteristics that influence the occurrence or scale of conflict have been documented for eight of the conflict species (all except caracal). There is a general consensus that depredation increases with

increasing proximity to natural habitat types that provide suitable cover for felids (Mizutani, 1995; Rao et al., 2002; Stahl et al., 2002; Vijayan & Pati, 2002; Athreya et al., 2004; Madhusudan, 2003; Nugraha, 2005; Michalski et al., 2006; Woodroffe et al., 2007). Depredation rates also tend to decrease with increasing proximity to human habitation (Sunde et al., 1998; Mazzoli et al., 2002; Rao et al., 2002; Stahl et al., 2002; Kolowski & Holekamp, 2006; Michalski et al., 2006). The effect of other landscape characteristics, for example crop type (Vijayan & Pati, 2002) or features for which a felid species may have a particular affinity such as play trees (Marker et al., 2003b), water bodies (Johnson et al., 2006; Michalski et al., 2006), steep rocky slopes (Stahl et al., 2002) or cliffs (Jackson et al., 1996), on rates of depredation, attacks on humans or retaliatory killing, receive less attention in the literature, making the identification of further trends difficult. However, reports indicate a degree of inter-specific variation in the influence of landscape characteristics, as would be expected from species' differing ecological habits.

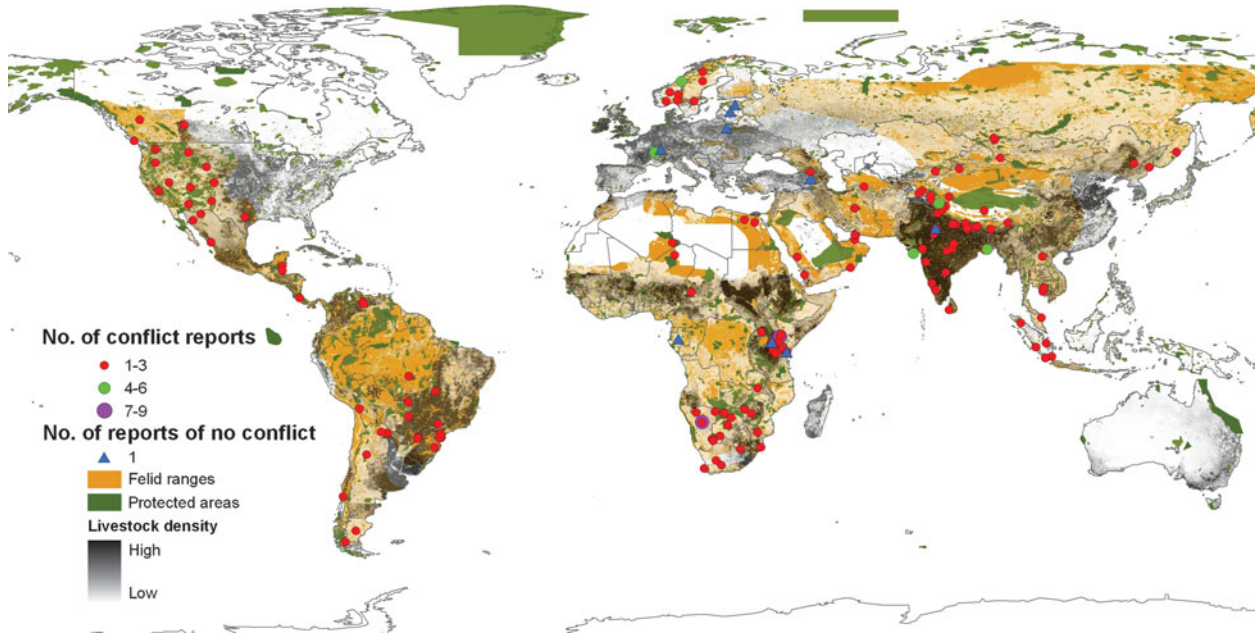


FIG. 6 Global overview of locations for which conflict (circles) or no conflict (triangles) have been reported in the literature reviewed. At each location mapped there may be conflict with more than one felid species and there may be reports of both conflict and no conflict at a given location as these will be for different species. The number of reports per location is detailed to provide an indication of the clustering of research efforts to date. Livestock density data represent the density of cattle and small ruminants globally as these are the most commonly attacked species. For data sources see Appendix 1.

Other determinants of conflict Many species- or location-specific factors influence the scale of conflict but consistent patterns could not be identified. Temporal patterns of conflict, predominantly in livestock depredation, have been described for all of the conflict felids (Oli et al., 1993, 1994; Jackson, 1999; Bauer & Kari, 2001; Nybakk et al., 2002; Madhusudan, 2003; Polisar et al., 2003; Melville et al., 2004; Mohd-Azlan & Sharma, 2006) but they are extremely varied and even differ between populations of the same species. For example, leopard attacks on livestock occur at night around Kenya's Maasai Mara National Park (Kolowski & Holekamp, 2006) yet in Laikipia they also occur during the day (Woodroffe et al., 2007). Other highly specific conflict determinants include: particular felid behaviours and adaptations (Jobin et al., 2000), poor anti-predatory behaviour of livestock (Srivastaav, 1997), environmental phenomena such as drought and floods (Frank & Woodroffe, 2002; Hoogesteijn & Hoogesteijn, 2007), and a lack of wildlife knowledge in communities with whom there is conflict (Hunter et al., 2007). Unsuccessful mitigation techniques have also been known to exacerbate conflict levels (Athreya et al., 2004).

Human-felid conflict management

A detailed review of conflict management strategies is beyond the scope of this article. However, we observed that 110 conflict management attempts were documented in 74

literature sources; of which 31% had been evaluated and the results documented in the primary literature (Table 4).

Discussion

Species affected & the extent of conflict

According to our review and classification, conflict affects 29 of the 37 felid species worldwide. The severity of conflict increases with felid species' body mass and is therefore of greatest significance for the conservation of the larger species. The only anomaly in this pattern is the caracal: despite having an average body mass of 17 kg we found human-caracal conflict to be of a moderate level, yet the slightly heavier bobcat (17.5 kg) is only affected by low levels of conflict. This may be explained by their prey preferences; the *Lynx* species are thought to have evolved to prey on lagomorphs (Jobin et al., 2000) and bobcats specialize on cottontails (*Sylvilagus* spp.) and snowshoe hares (*Lepus americanus*; Sunquist & Sunquist, 2002) and rarely attack livestock (Nowell & Jackson, 1996; Neale et al., 1998; Luna-Soria & López-González, 2005). Caracals, while also preferring small mammal prey, have broader diets than bobcat and are capable of killing larger prey such as springbok *Antidorcas marsupialis* or young kudu *Tragelaphus imberbis* and *T. strepsiceros* (Nowell & Jackson, 1996). We also classed conflict with both clouded leopard species (21 kg) as being of a low level as we could find few reports on

TABLE 4 Implemented and evaluated human-felid management strategies as documented in the literature reviewed. Each technique employed at a location is classed as an attempt. A literature source may evaluate the success of more than one technique. Seventy-four literature sources included details of implemented mitigation techniques; 21 (28%) provided an evaluation of techniques. Overall, 31% of all implemented techniques were evaluated and the results published in the primary literature.

Management type	Attempts	Examples of implemented strategies	No. of attempts evaluated (% total attempts)	Conclusion from evaluations (no. of attempts: no. evaluated)
Financial	34 attempts; 15 countries; 7 species	Compensation, insurance, economic development or incentive schemes, ecotourism, trophy hunting	5 (15)	Compensation schemes (20:2) generally unsuccessful (e.g. Madhusudan, 2003) but occasionally experience success under certain conditions (Hermann, 2003); economic incentive schemes (11:2) are proving successful (Mishra et al., 2003); preliminary results indicate insurance schemes (3:1) are a promising technique (Mishra et al., 2003) but less successful attempts have been documented (Miquelle et al., 2005)
Livestock husbandry	17 attempts; 10 countries; 8 species	Improved productivity & protection, e.g. synchronization of calving seasons, immunization, community livestock dip programme, bomas/corrals	6 (35)	Generally effective; success of techniques varies between species (Ogada et al., 2003; Woodroffe et al., 2007)
Livestock guarding	16 attempts; 6 countries; 6 species	People or dogs (either livestock herding or guarding dogs) protecting livestock	11 (69)	Successful (Vandel et al., 2001; Ogada et al., 2003; Marker et al., 2005a,b,c; Woodroffe et al., 2007)
Education & community development	5 attempts; 5 countries; 3 species	Community outreach & education initiatives; provision of grants for community development in exchange for community-wide agreements to safeguard livestock & protect wildlife	1 (20)	Education initiatives in Namibia significantly reduced numbers of cheetahs removed by farmers per year (Marker et al., 2003a)
Deterrents	5 attempts; 4 countries; 5 species	Scarecrows; lights & loud noises; pyrotechnics; face masks	2 (40)	Scarecrows associated with increased risk of attack on livestock (Woodroffe et al., 2007)
Barriers	8 attempts; 7 countries; 7 species	Specialized electric fencing; fences preventing cattle entering forests; wire mesh, wooden pole or nylon netting barriers around villages	2 (25)	Varied success depending on barrier structure and felid species (Schiaffino et al., 2002; Scognamillo et al., 2002)

Table 4 (Continued)

Management type	Attempts	Examples of implemented strategies	No. of attempts evaluated (% total attempts)	Conclusion from evaluations (no. of attempts: no. evaluated)
Aversive conditioning	4 attempts; 4 countries; 3 species	Electrified human dummies or stuffed animals; recently killed livestock injected with nauseating substances, e.g. lithium chloride	0	
Translocation	6 attempts; 6 countries; 4 species	Translocation of problem animals to protected areas/ areas a distance from human habitation	4 (67)	Unsuccessful (Rabinowitz, 1986; Athreya et al., 2004; Athreya & Belsare, 2007) or mixed success (Ruth et al., 1998; Goodrich & Miquelle, 2005)
Lethal control	5 attempts; 5 countries; 3 species	Selective removal or regulated harvest of felids	2 (40)	Selective removal not ideal (Stahl et al., 2001a), non-selective removal unsuccessful (Sunde et al., 1998; Herfindal et al., 2005)
Zoning	5 attempts; 3 countries; 4 species	Harvest Management Units; separating livestock grazing from felid habitat	0	
Land-use	1 attempt; 1 country; 1 species	Proactive agriculture extension, livestock grazing-free areas, resettlement	0	
Attack verification	1 attempt; 1 country; 1 species	Tiger Response Units	0	
<i>Total</i>	107 attempts		33 (31)	

depredation; however, the lack of information about these species makes this a tentative conclusion.

Spatial, taxonomic & socio-economic patterns of conflict

Reviewing conflicts between humans and mammalian and avian predators, Graham et al. (2005) found that resolution of trends was limited by inconsistent and sparse data, and highlighted the need for a consistent framework for assessing and managing human-predator conflicts that involve game and livestock species. Even at the more specific taxonomic level of our review, meta-analysis was not possible because of inconsistent reporting methods and disparity in the spatial scale of reports, making data generally incomparable either within or between felid species. A lack of comparable data particularly hampered our attempts to identify patterns and trends in livestock depredation. It appears, however, that while for some species, such as Eurasian lynx, there is variation in the number of livestock killed across their range, for others such as jaguars or snow leopards, the numbers killed are more consistent. No further trends were identified. Similarly, the varied economic reporting methods meant that comparing economic loss across locations, to identify those communities most greatly affected financially by conflict, was not possible.

The consistency in reporting technique was greater for data concerning attacks on humans and retaliatory killing than for livestock depredation, and again indicates geographical and inter-specific variation in attack and persecution rate. Although it has not been possible to identify further trends in retaliatory killings worldwide, it is apparent that persecution remains a significant threat to the nine conflict felids. For example, conflict is a principal threat to cheetahs in nine range countries in Africa and Asia (Marker, 1998), the lion population in Laikipia, Kenya, is regulated by lethal control in response to livestock depredation, rather than natural mortality rates (Woodroffe & Frank, 2005), and the retaliatory killing of snow leopards by farmers in Baltistan, Pakistan, poses a significant threat to the species' survival in the region (Hussain, 2000). In most parts of species' ranges however, the extent of retaliatory killing is unknown (Hussain, 2003; Breitenmoser et al., 2007).

Factors that determine the scale of conflict

The factors that determine the nature of a conflict are diverse. As many of these are location- or species-specific, a unique combination of factors determines the nature of a given conflict. The socio-economic factors fundamental to the human dimension of conflict, and that ultimately determine the scale of a given conflict, can be particularly varied, and identification of these factors is difficult. For example, in Scandinavia, although economic loss provides a prox-

imate reason for killing felids, it is apparent that retaliation results from a general antipathy for the Eurasian lynx (Andrén et al., 2006), and other cultural or economic influences such as traditional lion hunts, or *Olamayio*, in Kenya (Frank et al., 2006), or the potential to derive income from the sale of tiger body parts (Karanth & Gopal, 2005; Nugraha, 2005), must also be taken into consideration.

The scope of human-felid conflict literature

The amount and quality of human-felid conflict-related literature per species increased with felid body weight and therefore information about the smaller felid species with which conflicts are also likely is scarce. For example, ocelot *Leopardus pardalis*, margay *L. weidi*, jaguarundi *Herpailurus yagouaroundi* and Geoffroy's cat *Oncifelis geoffroyi* have a propensity to kill poultry but there is no published research to clarify the occurrence, extent or scale of the conflict (T. de Oliveira, pers. comm.).

Research has focused more on livestock depredation than attacks on people, persecution or game depredation, yet the economic impact of livestock depredation is rarely quantified. When it is, only the direct financial costs of livestock depredation are considered. However, it is recognized that economic losses can be catastrophic, particularly as they are often not evenly distributed throughout a community (Thirgood et al., 2005). There are also few instances in which the impacts of conflict are placed in a wider context through comparison with, for example, other factors that may limit livestock production (Hoogesteijn et al., 1993; Schiess-Meier et al., 2007), human deaths caused by other wildlife or domestic dogs (Beier, 1991), or natural or accidental (e.g. collisions with cars) causes of felid mortality (Marker et al., 2003a; Marker & Dickman, 2004; Miquelle et al., 2005).

A geographical analysis of human-felid conflict research efforts shows that there are vast areas of felid ranges for which no information on conflict is available and also that accurate distribution data for many species are not readily available (e.g. there are discrepancies between the caracal range data we were able to access, and the reported conflict locations for the species; Fig. 5d), which may hinder efforts to target future human-felid conflict research effectively. Additionally, obtaining accurate conflict data can be challenging as people may not be willing or able to report an accurate offtake by felids (A. Zimmermann, unpubl. data) or readily divulge whether they kill felids (Allen et al., 2002), and it can be difficult to determine the cause of livestock deaths (Madhusudan, 2003).

Conflict management: implementation & evaluation

We grouped the large and diverse number of conflict management techniques into 12 categories depending on

the type of technique involved. The effectiveness of techniques varies and, over time, shifts in the types of techniques have occurred. Historically, lethal control was the dominant type of conflict management. It is still used in the USA and Europe to control puma and Eurasian lynx populations respectively, despite questions about the effectiveness of such measures (Sunde et al., 1998; Stahl et al., 2001b; Hoogesteijn, 2003; Herfindal et al., 2005). More recently, compensation schemes have been the most commonly implemented strategy but have largely been unsuccessful. Other financial techniques such as insurance and economic incentive or development schemes are now being more heavily relied upon (Hussain, 2000; Jackson & Wangchuk, 2004), and preliminary results indicate that economic incentive schemes in particular are achieving success (Mishra et al., 2003). The use of guarding or herding dogs is one of the most consistently successful livestock husbandry-related techniques (Vandel et al., 2001; Ogada et al., 2003; Marker et al., 2005a,b,c). Conversely, translocations are generally ineffective (c.f. Linnell et al., 1997) and may even aggravate conflict levels (Athreya et al., 2004).

It is also apparent that little rigorous scientific information about the success and failings of the techniques is available. Thorough monitoring and evaluation of implemented management techniques is essential if practitioners are to identify the most successful and efficient methods of managing conflict, yet by our calculation only 31% of implemented techniques have been thoroughly evaluated and the results made available to the conservation community through publication. This number may in reality be even lower as it is likely that conflict mitigation techniques are being employed in more places than documented in the literature.

Conclusion

Human-felid conflict is a complex and multifaceted issue, the management of which is a key conservation priority for at least nine felid species. Many different conflict management strategies have been implemented worldwide, with varying degrees of success. To address conflict more effectively, practitioners must develop culturally acceptable, sustainable solutions, developed using not only sound scientific research but the practical field experience of other practitioners. Such solutions must aim to accommodate the requirements of both felids and people and reduce the costs incurred by both as a result of conflict.

We have highlighted three needs that are fundamental to the development of successful management strategies. Firstly, the development of standardized reporting techniques to allow comparison of the scale of conflict between locations and between species. This is particularly required for livestock depredation, which is the most commonly

reported aspect of conflict but for which there is the greatest disparity in reporting methods. The reporting of livestock losses to a particular predator as a proportion of total holdings, for example, would facilitate comparisons between livestock owners at all economic scales, and would also indicate where losses have the greatest financial impact.

Secondly, although general principles can be applied to conflict management strategies worldwide, variation in the determinants of conflict at each location dictates that strategies must be situation-specific. For example, while the effects of certain conflict determinants, such as habitat availability, appear uniform across species, and other determinants such as wild prey availability are a common influence on conflict severity, variation in the spatial, temporal and socio-economic determinants of conflict is evident, making each conflict situation unique. A thorough exploration of the conflict determinants at each location is therefore essential, and must result in a management strategy tailored to the situation to achieve maximum impact.

Thirdly, implemented management techniques should be evaluated rigorously and the results, even if they are negative, made available through publication. Communication between conflict practitioners is also essential for the transfer of knowledge regarding the successes and failures of applied techniques.

We have also highlighted a number of gaps in knowledge that must also be addressed if conflict management techniques are to become more efficient and effective. We propose that future research efforts should therefore:

- Seek to clarify the extent of conflict with the smaller felid species, and the species for which we currently have little information, such as the clouded leopards.
- Target range areas for which we currently have no information, to provide a range-wide overview of conflict for each species. Such efforts will be aided by accurate distribution data for felid species and, where not already available, efforts should be made to determine current species' distributions and the data made widely available.
- Focus more on understanding the patterns, trends and extent of attacks on people by felids worldwide.
- Investigate the extent to which game depredation by felids incites conflict, and the locations and felid species for which it is of greatest significance.
- Aim to understand better the human dimensions of conflict, and particularly the socio-economics, through greater collaboration with the social sciences.
- Quantify the extent of persecution of felids and assess its impact on felid population dynamics in those areas for which there is currently no information.

If the needs and knowledge gaps identified by this review are addressed, the knowledge gathered will increase our

understanding of the scale, occurrence and determinants of conflict worldwide. It will enable the more effective allocation of resources to target those species for which conflict is of greatest threat and/or the particular locations where conflict is having the greatest impact on both humans and felid species. Ultimately, the impact of implemented conflict management techniques will be increased, strengthening conservation efforts for members of the Felidae.

Acknowledgements

Funding for this research was provided by the North of England Zoological Society (Chester Zoo). Our particular thanks go to Scott Wilson for his invaluable GIS tuition and to Drs Lesley Morrell and Paul Johnson for their advice and assistance with statistical analysis. We would also like to thank Dr Alexander Sliwa, Dr Jim Sanderson, James Murdoch, Steve Ross, Tadeu de Oliveira and Anna Barashkova for the information on many of the smaller felid species.

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Appendices 1-4

The appendices for this article are available online at <http://journals.cambridge.org>

Biographical sketches

CHLOE INSKIP is carrying out research on human-carnivore conflicts in tropical forest habitats. At the time of writing she was based at Chester Zoo, UK, assisting with the development and coordination of the Zoo's felid conservation programmes. She is interested in wild cat conservation, and in particular, human-felid conflict. ALEXANDRA ZIMMERMANN specializes in human-wildlife conflicts, both in theory and practice. Having worked on jaguar conflict in Brazil and developed a successful long-term human-elephant conflict mitigation programme in India, her current research focuses on conflict dynamics, and conceptual models for best practice in conflict mitigation, in particular for large cats and elephants. For the past decade she has developed conservation programmes for Chester Zoo in the UK and is now based at the Wildlife Conservation Research Unit, Oxford University, UK.

Appendix 4:

Jaguars, livestock and people in Brazil: reality and perceptions behind the conflict.

Cavalcanti, S., Marchini, S., Zimmermann, A. , Gese, E.M. & Macdonald, D.W. (2010).

Jaguars, livestock and people in Brazil: reality and perceptions behind the conflict. *Biology and Conservation of Wild Felids*. Eds D.W. Macdonald & A.J. Loveridge. Oxford University Press. Oxford UK. 383-402

Jaguars, livestock, and people in Brazil: realities and perceptions behind the conflict

Sandra M. C. Cavalcanti,* Silvio Marchini,* Alexandra Zimmermann,
Eric M. Gese, and David W. Macdonald



Jaguar on a riverbank, Paraguay river, Pantanal, Brazil. © Edson Grandisoli.

Introduction

The jaguar (*Panthera onca*) is the largest predator in the Neotropics and is arguably the most charismatic species for conservation in Central and South America. Regrettably, the jaguar is also the carnivore that is least compatible with humans in twenty-first-century Brazil. This fundamental incompatibility is due to the jaguar's need for abundant, large prey, as well as extensive, undisturbed habitat. Humans (also large, top predators) have competed directly with jaguars for food (i.e. native and domestic ungulates) for as long as they have coexisted (Jorgenson and

Redford 1993), and lately threaten them directly and indirectly through deforestation and habitat fragmentation. Moreover, jaguar predation on livestock (particularly cattle) (Fig. 17.1) provokes retaliatory persecution by humans (Hoogesteijn and Mondolfi 1992).

Persecution looms as the *coup de grace* to jaguar populations outside protected areas (Nowell and Jackson 1996) and, due to their wide-ranging movements, threatens jaguars within protected areas as well (Woodroffe and Ginsberg 1998). Although disentangling the contributions of persecution and habitat loss may be difficult, jaguar distribution

* Sandra Cavalcanti and Silvio Marchini are joint first authors.



Figure 17.1 A jaguar stands over a young calf that it has killed on a ranch in the southern Pantanal. © Pantanal Jaguar Project archive.

(Fig. 17.2) and abundance have declined drastically in recent decades (Hoogsteijn and Mondolfi 1992). Our case study focuses on Brazil, where the jaguar is a threatened species (Machado *et al.* 2005), although internationally it is classed as near threatened (i.e. it may be threatened with extinction in the near future; IUCN 2007).

Efforts to protect jaguars by curbing persecution by humans have been based on what might be termed a ‘bio-rational’ understanding of the problem. Insofar as the root of the problem is livestock-raiding then, so this rational goes, if we can find ways to effectively reduce jaguar predation on cattle (e.g. by the use of electric fences, aversive conditioning, and translocation), then persecution by cattle ranchers should subsequently decline (Cavalcanti 2003; Hoogsteijn 2003). Preventative actions combined with monetary compensation to ameliorate the financial costs of lost livestock are aimed at alleviating the economic burden on ranchers who coexist with jaguars, on the assumption this will reduce the motivation for ranchers to kill them.

Although this bio-rational thinking may be plausible to a scientifically trained conservationist, we hypothesized that human persecution of jaguars may be less related to livestock depredation than previously believed, and the economic justification for killing jaguars may be equally unclear. We argue that the ultimate motivator of retaliatory persecu-



Figure 17.2 Current (black) and historical (dark grey) jaguar distribution range.

tion may not be the actual impact of jaguars on human safety or livestock, but rather the cultural and social perceptions of the potential threat that

jaguars pose when attacking humans and killing livestock. In conflicts between people and carnivores, the perceived impacts often exceed the actual evidence (Conover 2001; Chavez and Gese 2005, 2006; Chavez *et al.* 2005; Sillero-Zubiri *et al.* 2007). In addition, factors not directly related to the impacts that jaguars have on human livelihoods (e.g. perceived social status of jaguar hunters in the community and thrill of the chase) may also be involved in the persecution of jaguars, making evaluations for the economic rationale for killing jaguars even more unclear. Such imprecise linkages between reality and perception could prove perilous to a threatened species, adding a potentially lethal element to already significant risks posed by retributive killing, and rendering irrelevant many biologically based conservation actions and mitigation measures.

To explore this 'perception blight', this chapter addresses the realities and perceptions behind the conflicts involving jaguars, livestock, and cattle ranchers in Brazil. We use the Pantanal region to quantify the importance of cattle in jaguar ecology, and techniques adapted from the social sciences to examine the ranchers' perceptions about jaguar depredation on cattle and other perceptions about jaguars and jaguar hunting that may be relevant in dealing with conflicts between ranchers and jaguars. We then investigate how these social and cultural perceptions may translate into the persecution of jaguars. Finally, we discuss how information on the ecological, economic, social, and cultural dimensions of a human–carnivore conflict can be fruitfully integrated into a strategy that encompasses both individuals and populations (of both jaguars and humans) in an attempt to promote coexistence between jaguars, livestock, and people.

Jaguars, livestock, and people

The jaguar occurs from the south-western United States to northern Argentina, across an area of 11.6 million km² and occupies a diverse array of habitats, including xeric shrublands, dry forests, montane grasslands, moist lowland forest, wet savannahs, and mangroves (Zeller 2007). Even though 36% of jaguar distribution overlaps protected areas (Zimmer-

mann and Wilson, in preparation), studies indicate that very few of these areas offer true protection from human influences for both jaguars and their prey. Indeed, the edges of protected areas often become hot spots for human–wildlife conflict (Woodroffe and Ginsberg 1998; Loveridge *et al.*, Chapter 11, this volume). The human geography outside these protected areas is varied so jaguars may coexist with people holding a range of different perceptions and levels of tolerance for wildlife. Outside protected areas, the most common land-use form is livestock ranches, followed by logging areas, forest matrix lands, agricultural areas, and other forms of land use (Zeller 2007). On a continental scale, jaguars occur mostly in areas with a low Human Footprint Index (HFI; 95% of jaguar range is in areas of <35 HFI), and low cattle densities (96% in areas with ≤ 7.5 cattle/km²; Zimmermann and Wilson, in preparation). Nevertheless, hunting of prey used by jaguars and direct human persecution of jaguars (most often in retaliation for livestock depredation) are, according to 130 jaguar experts, the most serious threats to the survival of the jaguar (Zeller 2007).

Conflicts between humans and jaguars occur in many different socio-economic and cultural contexts and vary in their severity, but appear to be most extensive in regions with large cattle ranches, where human densities are low, cattle densities are moderate, and small areas of wilderness containing natural prey still persist. There are several such vast rangelands in South America, most notably the Pantanal, Llanos, Beni, and Chaco regions of Argentina, Brazil, Bolivia, Colombia, Paraguay, and Venezuela. The best studied of the above regions of Brazil, the Pantanal, is the focus of our chapter.

Conflicts between ranchers and jaguars over livestock are widespread and have been documented throughout jaguar range (e.g. Belize: Rabinowitz 1986; Brazil: Crawshaw and Quigley 1991; Dalponte 2002; Conforti and Azevedo 2003; Michalski *et al.* 2006a; Azevedo and Murray 2007b; and Palmeira *et al.* 2008; Costa Rica: Saenz and Carrillo 2002; Argentina: Schiaffino *et al.* 2002; Venezuela: Scognamiglio *et al.* 2002; and Polisar *et al.* 2003). Nevertheless, several ecological, socio-economic, cultural, and historical aspects of the relationships between people and jaguars have made Brazil particularly important for jaguar research and conservation.

Conflict in Brazil

Brazil covers 40% of the land area of Latin America. Even though estimates of jaguar abundance are as scarce for Brazil (Almeida 1986; Quigley and Crawshaw 1992; Soisalo and Cavalcanti 2006) as for other parts of their range (cf. Wallace *et al.* 2003; Maffei *et al.* 2004a; and Silver *et al.* 2004), Brazil does contain the two largest population strongholds for jaguars (Sanderson *et al.* 2002b): the wetlands of the Pantanal (140,000 km²) and the rainforests of Amazonia (3,400,000 km²). The southern Pantanal of Brazil has the highest density of jaguars recorded (estimates range from 6.7 to 11.7 individuals/100 km²; Soisalo and Cavalcanti 2006). The Pantanal is also home to the largest jaguars, with the weight of males averaging 100 kg (females are typically 10–20% smaller than males) and the largest males reaching 158 kg (Seymour 1989). Jaguars were widely distributed throughout Brazil until 1500, but have since been extirpated from entire regions (Sanderson *et al.* 2002b; Fig. 17.2). Some jaguars still remain in fragments of the Atlantic forest and the Cerrado, but large jaguar populations are present only in Amazonia and the Pantanal, where human population density has historically been low.

Brazil is also home to the world's largest commercial cattle herd (>200 million head) and is the world leader in beef exports (Nepstad *et al.* 2006). Due to ecological and historical reasons, there is overlap between areas where beef production flourishes and jaguars survive, namely, the Pantanal and the agricultural frontier of southern Amazonia (Thornton *et al.* 2002). Cattle ranchers have a long tradition of killing jaguars (Hoogesteijn and Mondolfi 1992) in retaliation for livestock losses.

Cattle ranching also threatens jaguars indirectly, insofar as it is the major driver for the high and rapid level of deforestation in Amazonia, being the primary reason for >66% of habitat loss in the region (Nepstad *et al.* 2006). Between 1987 and 2006, an average of 18,000 km² of prime jaguar habitat was lost in this region every year, mostly from the Amazonian agricultural frontier (PRODES 2007). In the past two decades, Brazil has lost larger areas of jaguar habitat than any other country.

In 1967, the Brazilian Wildlife Protection Act prohibited commercial exploitation of wildlife and

wildlife products derived from their capture, pursuit, or destruction. The Convention on International Trade in Endangered Species (CITES) of 1973 made it illegal to trade jaguar skins or parts for commercial gain. The CITES listing, in combination with the Brazilian legislation and anti-fur campaigns, brought about a sharp decline in the fur trade, helping to reduce the pressure on jaguar populations in the wild. However, jaguar persecution continues (Crawshaw 2002; Michalski *et al.* 2006a), now very rarely for the illegal trade, but more because of their perceived threat to people and their livelihoods. The indiscriminate killing of jaguars is one of the most serious threats to their survival across all of Latin America (Zeller 2007).

Jaguars, livestock, and people have coexisted in Brazil for many decades across a wide range of ecological, cultural, and socio-economic settings. From small family-run farms in the dry Caatinga to commercial large-scale ranches in the wetlands of the Pantanal, from old traditional cattle ranches in the Atlantic rainforest to recent settlements on the Amazon agricultural frontier, Brazil is the perfect test tube in which to explore the interacting chemistry of jaguars, livestock, and people.

Pantanal

The Pantanal is located in the geographic centre of South America and spans the borders of Brazil, Bolivia, and Paraguay (Fig. 17.3). With a highly seasonal climate, the Pantanal receives an average of >1.2 m of rainfall annually, which causes vast amounts of areas to be flooded and a subsequent flush of green grasses to be available for both native and domestic ungulates. The Pantanal is characterized by savannahs interspersed with isolated islands of secondary forest, which are an important refuge for both predators and prey. Gallery forests border temporary and permanent rivers and provide long corridors for wildlife movement.

Almost a third of published scientific articles on jaguar biology and conservation concern Brazil. While these topics have been addressed in the Brazilian Amazon (Oliveira 2002b; Michalski *et al.* 2006a), Cerrado (Silveira and Jacomo 2002; Palmeira *et al.* 2008), and Atlantic Rainforest (Garla *et al.* 2001; Leite

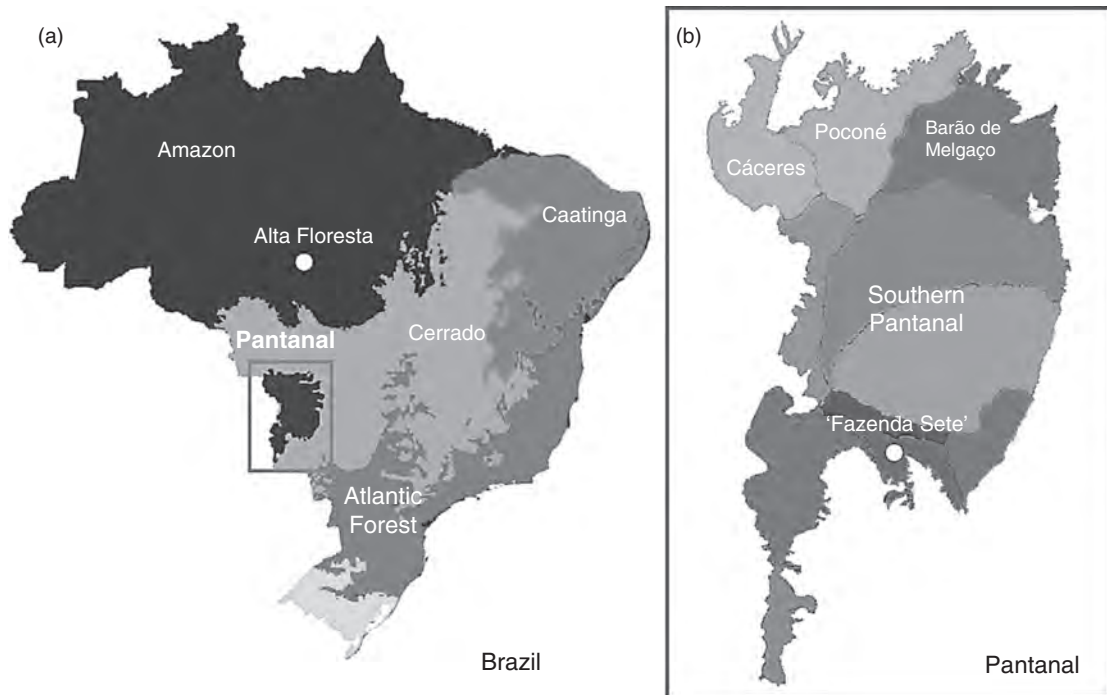


Figure 17.3 (a) Map of Brazil showing major biomes, the Amazon study site (Alta Floresta), and the Pantanal (highlighted by the box); and (b) map of the Pantanal showing its subregions. This study was conducted in the three subregions of northern Pantanal, namely Cáceres, Poconé, and Barão de Melgaço, and a ranch in southern Pantanal ('Fazenda Sete').

et al. 2002; Conforti and Azevedo 2003; Crawshaw *et al.* 2004; Cullen *et al.* 2005), the Pantanal accounts for the greatest portion of publications about jaguars (e.g. Schaller and Vasconcelos 1978; Schaller 1979, 1983; Schaller and Crawshaw 1980; Crawshaw and Quigley 1984, 1991; Crawshaw 1987, 2002; Quigley 1987; Quigley and Crawshaw 1992, 2002; Dalponte 2002; Zimmermann *et al.* 2005a; Soisalo and Cavalcanti 2006; and Azevedo and Murray 2007a, b, and Cavalcanti and Gese 2009).

In this landscape mosaic, cattle have been ranched for >200 years (Wilcox 1999). The Pantanal consists almost entirely of large cattle ranches (e.g. average ranch size 12,950 ha, SE = 22,444 ha; Zimmermann *et al.* 2005a). Cattle are raised extensively in the region, with an average cattle density of 16 head/km² (Mourão *et al.* 2002). People and jaguars, however, have coexisted uneasily. Jaguars have long been blamed for killing cattle and, in the past, ranch owners employed men solely to hunt jaguars. The extent of retaliation by ranchers was considerable. For ex-

ample, in the early 1980s, 68 jaguars were killed over 8 years on one ranch alone (P. Crawshaw, as cited in IUCN/SSC 1986). Whether as a result of governmental legislation or the economic crisis in cattle ranching caused by the severe flood of the 1970s, the rate at which jaguars are killed appears to have declined and jaguar abundance in the Pantanal appears to be increasing (Crawshaw 2002). Nonetheless, as ranchers own 95% of this vast region, the future of jaguars in the Pantanal is inextricably linked to the ranchers' perceptions and attitudes towards them.

Assessing the realities and perceptions behind the conflict

In this chapter, we will attempt to weave together findings from several studies conducted by the authors between 2000 and 2008 which explored

human–jaguar conflict in the Pantanal and the Amazon from various perspectives: jaguar predation rates on a cattle ranch, perceptions and attitudes of ranchers towards jaguars and livestock losses, and the various factors that may shape human beliefs and behaviour towards jaguars.

To document the realities of jaguar predation on livestock and native prey, the Pantanal Jaguar Project quantified kill rates, composition of prey killed, characteristics of prey killed, and patterns of predation on a ranch in the southern Pantanal ('Fazenda Sete' in Fig. 17.3; Cavalcanti 2008). In addition, Global Positioning System (GPS) telemetry provided information on jaguar movements (Cavalcanti and Gese 2009) and facilitated analysis of habitat use and spatial patterns of predation (on both domestic and native species) in relation to the type and distribution of vegetation and other landscape attributes (Cavalcanti *et al.*, in preparation). Ten jaguars were equipped with GPS radio-collars (Televilt, Sweden), which recorded their locations at 2-h intervals, enabling us to identify kill sites and thereby to find and document 438 carcasses of prey (including the identity of the predator, the date and approximate time of death, the period for which the predator stayed by the carcass, and the vegetation cover at the kill site; Cavalcanti 2008; Cavalcanti *et al.*, in preparation).

Meanwhile, the Coexistence Project studied the factors determining people's perceptions of jaguars and how these perceptions translated into human persecution of jaguars. Interviews with ranchers were used to document the following: (1) socio-demographic variables; (2) description of the property; (3) respondents' knowledge about jaguars and depredation problems; and perceptions of the jaguars' impact on (4) livestock; and (5) human safety; together with perceptions of (6) an increase in jaguar abundance; (7) degeneration of economic situation; (8) the social acceptability/desirability of persecuting jaguars, including the importance of traditional jaguar hunting; (9) the ease or difficulty of this persecution; (10) attitudes towards both jaguars and persecution; and (11) intention to persecute jaguars. Answers in either a binary yes/no or in 3- or 5-point scale formats enabled us to construct measurement scales (0 to 10 for knowledge and perceptions and –10 to 10 for attitude) and combine responses into an additive score for each variable (the higher the score the greater the knowl-

edge or perception and more positive the attitude). In order to assess the degree to which the findings from the Pantanal can be extrapolated to other regions or whether attitudes are culturally specific to human–jaguar conflicts, we replicated this study on an agricultural frontier area in southern Amazonia (municipality of Alta Floresta). Like the Pantanal, the Amazon site hosts relatively high densities of both jaguars and livestock, but as a recently established agricultural frontier it differs in many social and cultural aspects from the Pantanal. Unlike the Pantanal, habitat loss is a major threat to jaguars on the Amazon frontier. This study involved 45 ranchers in two sub-regions of the northern Pantanal (Cáceres and Poconé) and 106 ranchers in Amazonia (Fig. 17.3; Marchini and Macdonald, in preparation-a).

We also examined the attitudes and conservation values of 50 ranchers from an earlier study in the three subregions of the northern Pantanal, namely, Cáceres, Poconé, and Barão de Melgaço (Fig. 17.3). In this study, we investigated the associations between attitudes and socio-economic variables such as rancher age, ranch size, cattle herd size and density, reported cattle losses, and level of involvement in tourism. Attitudes were explored using a series of suggested statements regarding jaguars and conservation, and responses were recorded on a five-point Likert scale so that they could be combined into an additive score, and the relationships between the combined score and potential explanatory variables could be analysed (Zimmermann *et al.* 2005a).

Realities of jaguar foraging ecology

Radio-tracking (Cavalcanti 2008) revealed that native species comprised 68.3% of the prey killed, with the remainder being cattle (31.7%). For individual jaguars, the number of cattle killed varied widely among cats (Fig. 17.4). Individuals also differed in the species diversity of their diets; although collectively the 10 jaguars killed 24 prey species, some killed few prey species, while others killed many (Table 17.1). Jaguars killed predominantly ungulates, but they also killed and consumed other predators, such as maned wolves (*Chrysocyon brachyurus*), crab-

eating foxes (*Cerdocyon thous*), coati (*Nasua nasua*), and raccoons (*Procyon cancrivorus*).

Based on kills reported by ranch hands, Crawshaw and Quigley (2002) calculated that cattle comprised 46% of jaguar kills in the southern Pantanal. In their data, small prey was probably under-represented as these may be killed and consumed in secluded sites (see also Schaller 1979). This bias might also affect our findings, which included a small proportion of the biomass killed and consumed (e.g. birds; caiman lizard, *Dracaena paraguayensis*; coati; small anaconda *Eunectes notaeus*; and armadillo, *Euphractus sexcinctus* and *Dasyfus novencinctus*). Homing in on radio-collared jaguars, Crawshaw and Quigley (2002) found 17 prey items of which 29% were cattle and 41% were white-lipped peccaries (*Tayassu pecari*)—a close match to our overall finding of cattle accounting for 31.7% of jaguar kills, but varying seasonally between 19.2% and 48.9%, respectively, for the wettest and driest periods of the 4-year field study (Cavalcanti 2008).

Calves (<1 year old, <174 kg) accounted for 69% of cattle killed by jaguars (Cavalcanti 2008), which is higher than Crawshaw and Quigley (2002) reported (43%) in their study in the same area in the southern Pantanal; perhaps again due to bias in carcass detection or annual variation. These findings from the Pantanal are broadly consistent with those reported elsewhere. In Venezuela, jaguars attacked young cattle (weaned calves and heifers 1–2 years of age) more often than they did adults (Hoogesteijn *et al.* 1993;

Farrell 1999; Scognamillo *et al.* 2002). In north-east Argentina, cattle between 1 and 3 years comprised the majority of jaguar kills (Perovic 2002). Younger calves of 3–9 months of age comprised the majority of jaguar kills in northern Goiás, central-western Brazil (Palmeira *et al.* 2008). Azevedo and Murray (2007a) found that in the southern Pantanal predation risk was higher among calves up to 12 months of age.

Although jaguars can kill mature bulls (Hoogesteijn *et al.* 1993), we documented no jaguar attacks on an adult bull, and only one instance of jaguars scavenging on a bull carcass. Contrary to the beliefs of ranchers, the GPS data indicated that jaguars scavenged a proportion of their prey (we found six instances, involving three individuals, of feeding substantially from cattle that had died from other causes; see also Lopez-Gonzalez and Piña 2002). Therefore, scavenging complicates the interpretation of diet analyses based on undigested remains in jaguar faeces.

At 19 kill sites located by GPS-tracking, the remains of two different prey species were found (Cavalcanti 2008). We deduced this might have occurred when a jaguar killed a species scavenging from the original kill, and in 79% of these occasions this was a plausible explanation (e.g. one of the carcasses was a potential scavenger, such as feral hog, *Sus scrofa*; peccary; armadillo; raccoon; or caiman, *Cayman crocodylus yacare*). This ‘scavenger-trap’ hypothesis seemed inappropriate for the remaining 21% of

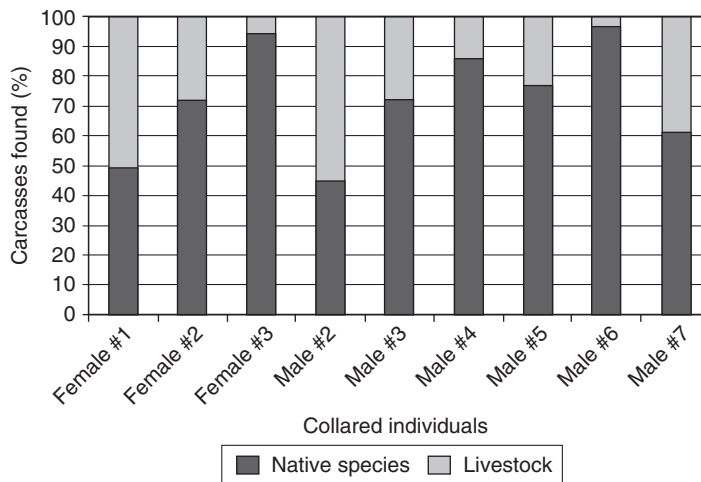


Figure 17.4 Distribution of native prey species and livestock killed by collared jaguars, November 2001 to April 2004, southern Pantanal, Brazil. (From Cavalcanti 2008.)

Table 17.1 Distribution of prey species (n [percentage of kills]) detected at kill sites for 10 individual jaguars, November 2001 to April 2004, southern Pantanal, Brazil.

Prey	Adult female					Adult male					Subadult male #6 (n = 27)
	#1 (n = 80)	#2 (n = 123)	#3 (n = 22)	#4 (n = 5)	#1 (n = 47)	#2 (n = 36)	#3 (n = 18)	#4 (n = 40)	#5 (n = 36)		
Tapir, <i>Tapirus terrestris</i>	0	0	0	0	0	0	0	1 (2.50)	1 (2.78)	0	
Birds ^a	0	1 (0.81)	0	0	1 (2.13)	1 (2.78)	0	0	0	0	
Calif <i>Bos taurus</i>	30 (37.5)	18 (14.6)	0	3 (60.0)	24 (51.1)	3 (8.33)	2 (11.1)	7 (17.5)	1 (2.78)	6 (22.2)	
Capybara <i>Hydrochoerus hydrochaeris</i>	4 (5.0)	1 (0.81)	0	0	0	0	0	1 (2.50)	0	3 (11.1)	
Marsh deer, <i>Blastocercus dichotomus</i>	3 (3.75)	2 (1.63)	1 (4.54)	0	4 (8.51)	1 (2.78)	0	2 (5.0)	0	3 (11.1)	
Maned wolf, <i>Chrysocyon brachyurus</i>	2 (2.50)	1 (0.81)	0	0	0	0	0	0	0	0	
Land turtle, <i>Geochelone carbonaria</i>	1 (1.25)	0	0	0	0	0	0	0	0	0	
Caiman, <i>Cayman crocodylus yacare</i>	10 (12.5)	52 (42.3)	9 (40.9)	1 (20.0)	4 (8.51)	8 (22.2)	7 (38.9)	3 (7.50)	8 (22.2)	5 (18.5)	
Crab-eating fox, <i>Cerdocyon thous</i>	0	1 (0.81)	0	0	0	0	0	1 (2.50)	1 (2.78)	0	
Raccoon, <i>Procyon cancrivorus</i>	0	0	1 (4.54)	0	0	1 (2.78)	0	0	1 (2.78)	0	
Feral hog, <i>Sus scrofa</i>	3 (3.75)	4 (3.25)	1 (4.54)	0	6 (12.8)	1 (2.78)	1 (5.55)	2 (5.0)	1 (2.78)	0	
Coati, <i>Nasua nasua</i>	0	0	1 (4.54)	0	1 (2.13)	1 (2.78)	0	0	0	2 (7.40)	
Peccary ^b	7 (8.75)	23 (18.7)	5 (22.0)	0	4 (8.51)	11 (30.5)	6 (33.3)	14 (35.0)	20 (55.6)	2 (7.40)	
Anaconda, <i>Eunectes noctaeus</i>	0	0	0	0	0	0	0	0	0	1 (3.70)	
Giant anteater, <i>Myrmecophaga tridactyla</i>	7 (8.75)	2 (1.63)	0	0	1 (2.13)	3 (8.33)	0	0	1 (2.78)	0	
Lesser anteater, <i>Tamandua tetradactyla</i>	1 (1.25)	1 (0.81)	0	0	0	3 (8.33)	0	2 (5.0)	0	0	
Armadillo ^c	2 (2.50)	0	3 (13.6)	0	0	0	0	1 (2.50)	0	0	
Adult cattle, <i>B. taurus</i>	9 (11.2)	16 (13.0)	1 (4.54)	1 (20.0)	2 (4.25)	2 (5.55)	2 (11.1)	5 (12.5)	0	4 (14.8)	
Brocket deer ^d	1 (1.25)	0	0	0	0	1 (2.78)	0	1 (2.50)	2 (5.55)	1 (3.70)	
Caiman lizard, <i>Braconia paraguayensis</i>	0	1 (0.81)	0	0	0	0	0	0	0	0	

^a Includes an egret (*Egretta alba*), a jabiru stork (*Jabiru mycteria*), and a boat-billed heron (*Cochlearius cochlearius*).

^b Although collared peccaries (*Tayassu tajacu*) were present, the vast majority killed by jaguars were white-tipped peccaries (*T. pecari*).

^c Includes two species of armadillos present in the study area, *Euphractus sexcinctus* (n = 4) and *Dasyypus novencinctus* (n = 1).

^d Includes both species, *Mazama americana* and *Mazama ouazoubira*.

Source: From Cavalcanti (2008).

double kills, insofar as neither of the victims was a scavenger (e.g. calf; brocket deer, *Mazama* spp.; giant anteater, *Myrmecophaga tridactyla*; and lesser anteater, *Tamandua tetra dactyla*).

Jaguars are often considered nocturnal predators. However, we found the time of day at which jaguars killed was evenly distributed throughout the 24-h period, even when examining individual prey species (Cavalcanti 2008). Jaguars appear to be adaptable to the movement and activity patterns of various prey species and readily exploit these species when they are active or vulnerable to predation.

When examining the seasonality of predation patterns by jaguars, we found the average number of cattle, caiman, and peccaries (the three major prey species) killed by radio-collared jaguars each season indicated a peak of predation on cattle in the dry seasons of each year (Fig. 17.5; Cavalcanti 2008). The frequency of predation on caiman appeared to be constant throughout all months of 2002, while predation appeared to peak during the wet seasons (February–March) of 2003 and 2004. There may be an inverse relationship between predation on cattle and caiman; as water levels recede in the Pantanal,

caiman move with these levels and predation declines; conversely, as water levels recede cattle are moved into these areas for grazing and predation on cattle increases. The fluctuation of water levels is the major driver in this ecosystem, dictating the availability and vulnerability of prey species, including cattle. The frequency of predation on peccaries also appeared to be constant throughout 2002, then increased in 2003 and 2004. Seasonally, the mean number of peccaries killed each month appeared to be lowest during the wet seasons (February–March; Fig. 17.5). However, despite an apparent tendency for the number of cattle killed each month to have declined over the 4-year study, statistically the actual seasonal predation rates on cattle did not decline between 2002 and 2004 (Fig. 17.6). Conversely, while the data suggest an increase in the number of caiman killed each month, the observed seasonal predation rates on caiman did not increase statistically over the seasons. Predation rates on peccaries did increase significantly between the wet season of 2001–02 and the dry season of 2004 (Fig. 17.6). The increase in jaguar predation rates on peccaries during the study occurred during a period of relatively high

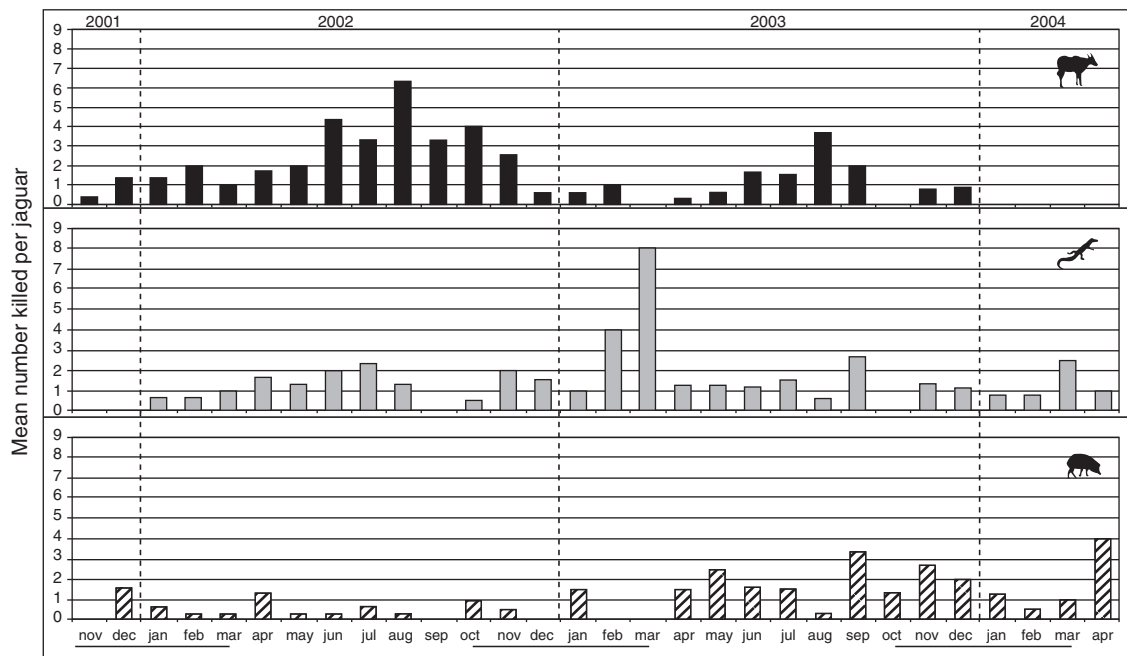


Figure 17.5 Distribution of the mean number of cattle, caiman, and peccary killed per month by collared jaguars, November 2001 to April 2004, southern Pantanal, Brazil. (From Cavalcanti 2008.)

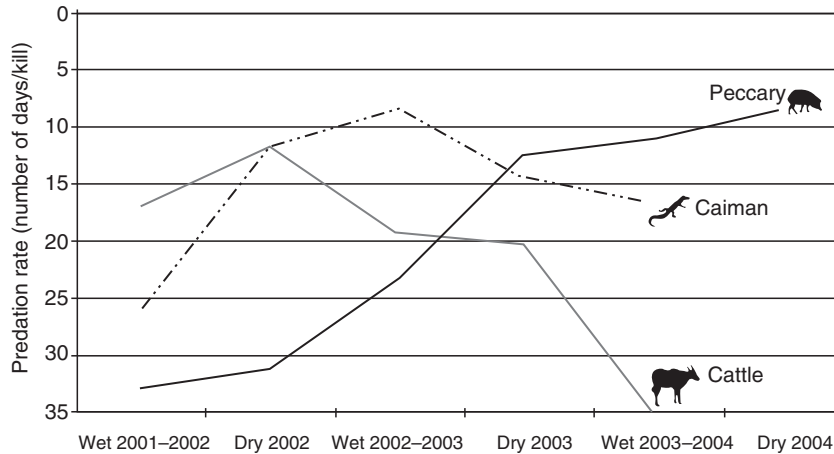


Figure 17.6 Seasonal variation in jaguar predation rates of caiman, peccary, and domestic cattle, November 2001 to April 2004, southern Pantanal, Brazil. (From Cavalcanti 2008.)

peccary densities (9.63 individuals/km²; Keuroghlian 2003). This increased predation rate on peccaries during the study suggests that the availability of alternative prey could reduce jaguar predation rates on cattle and could serve as a buffer species.

Because jaguars are ambush predators, an obvious prediction would be that kills were associated with dense vegetation. Cavalcanti *et al.* (in preparation) found that while the 10 GPS-collared jaguars used forests and shrublands preferentially, kills were made in habitats in proportion to their availability. Cattle, caiman, and peccaries killed by jaguars ($n = 327$) were distributed in the various habitat classes according to their availability, except during the dry season, when caiman and peccaries were mainly killed in shrublands and forests, respectively. Male and female jaguars consistently selected shrublands during both wet and dry seasons. Although there was little evidence that particular species were killed in particular habitats, there was a tendency for cattle to be killed further than expected from water.

Some authors have hypothesized that jaguar predation on cattle is a function of the distribution, availability, or proximity to forest habitat or forest edges (Rabinowitz 1986; Hoogesteijn *et al.* 1993; Michalski *et al.* 2006a; Palmeira *et al.* 2008). Hoogesteijn *et al.*'s comparison (1993) of three ranches in Venezuela led to the conclusion that jaguars killed cattle closer to forested areas. Rabinowitz (1986) reported jaguars readily killed dom-

estic livestock that entered forested areas, but not when cattle were in open pastures. Quigley (1987) reported cattle were killed only in gallery forests and forest patches, although some might have been dragged there from the forest edge. This differs from the findings of Cavalcanti *et al.* (in preparation) reported above, who found that during the wet season, cattle were killed by jaguars significantly closer to forest edges than in the dry season. During the wet season, cattle were able to forage in chest-deep water, but they needed dry ground on which to spend the night. Therefore, they might spend more time closer to forests, which are typically associated with higher and drier ground. Several authors have suggested keeping cattle herds away from forested areas as a strategy to minimize jaguar attacks (Rabinowitz 1986; Hoogesteijn *et al.* 1993; Michalski *et al.* 2006a; Palmeira *et al.* 2008), but at least in the Pantanal, we recorded jaguar attacks on cattle in other habitats as well (Cavalcanti *et al.*, in preparation).

Individual variation in jaguar diets: do 'problem animals' exist?

Since jaguars differed individually in their diet (Cavalcanti 2008), we examined whether some jaguars contributed more than others to the levels of

domestic stock losses (cf. Linnell *et al.* 1999). There was no straightforward answer. While prey remains of individual jaguars indicated that cattle comprised >50% of the diet for some individual jaguars, for others it did not exceed 5%. Nevertheless, each of the 10 radio-collared jaguars killed cattle. Whether or not killing the predominant cattle-killers would ameliorate the problem (e.g. as suggested by Rabinowitz 1986 and Hoogesteijn and Mondolfi 1992) depends on the causes of this individual variation (i.e. causes may include availability and vulnerability of prey, preference for particular prey species, or cultural learning from their mother). However, we also found that for some individuals that had >50% of their kills comprised of cattle in 2002 (a dry year), these same jaguars exhibited an appreciable decline in cattle kills in 2003 (a wet year). Again, water levels, and the consequent movement of both caiman and cattle, likely played an important role in the availability of these two key prey species within individual jaguar home ranges and therefore influenced encounter rates (Cavalcanti 2008).

Previous analyses of the variation in the level of livestock depredation suggest that males are more likely to kill cattle than are females (e.g. Rabinowitz 1986, Stander 1990, and Chellam and Johnsingh 1993). However, results from the 4 years of study found no differences between males and females in the level of predation on cattle (Table 17.1; Cavalcanti 2008). It is conceivable that jaguars, especially females, may kill cattle in excess of their needs, which might be considered a mechanism for teaching their young to hunt (A. Silva, V. Correia, A.T. Neto, and B. Fiori, personal communication). Surplus killing is almost universal amongst the *Carnivora* (Kruuk 1972), so it is unexpected that it has not been reported for jaguars. In general, the time interval between kills, and the time spent at each kill, was related to prey size (Cavalcanti 2008). After killing and consuming a small prey item, a jaguar generally killed again in a shorter time (3.0 days before making another kill) as compared to when they killed larger prey (5.1 days). Similarly, the length of time jaguars stayed at a carcass site significantly increased with increasing body mass of prey; 16.0 h were spent on small prey, increasing to 27.9 h on larger prey (Cavalcanti 2008). Some authors have speculated that livestock depredation is more prevalent among

subadult than adult felids (Rabinowitz 1986; Stander 1990; Saberwal *et al.* 1994), whereas others conclude adults are more likely to kill cattle than younger individuals (Bowns 1985; Esterhuizen and Norton 1985). In our study, stock killing occurred at a rather constant rate among individuals. On average, jaguars killed one calf every 13.3 ± 15.5 (SD) days, while adult cows were killed at a lower rate of 25.5 ± 18.4 (SD) days between kills, although these rates varied annually (Cavalcanti 2008). The level of rainfall in any given year appeared to be the most influential factor affecting individual jaguar predation rates on cattle by determining the availability of cattle on the landscape (Cavalcanti 2008). During wet years, native prey were also available to jaguars and cattle were less vulnerable to predation. Conversely, during dry years, cattle were more dispersed over the landscape, exposed to more jaguar territories, thereby increasing encounter rates between individual jaguars and domestic prey. In addition, the poorer condition of cattle influenced their vulnerability to predation during the dry years. Husbandry practices are also likely to have a large influence on jaguar predation. In the Pantanal, calves were generally born over several months, prolonging the time period over which vulnerability to jaguar predation was increased. In addition, pregnancy rates of cows are generally well below optimal, often between 60% and 75%. Native ungulates usually swamp predators by having a short birth pulse, thereby decreasing the length of time that young are exposed or vulnerable to predation. Shortening the birth pulse and increasing the number of pregnant cows within a cattle operation could, in theory, reduce overall predation losses within individual jaguar territories, where calving grounds are located by swamping an individual cat with far more prey than can be killed; assuming that satiation of the predator causes an asymptote in the kill rate.

A common hypothesis in terms of large cat predation on livestock is that it is prevalent among wounded or sick predators, and this idea has been mooted for jaguars (Rabinowitz 1986; Fox and Chundawat 1988; Hoogesteijn *et al.* 1993). Indeed, two studies in Venezuela both revealed that the majority of the jaguars (75% and 53%) killed as part of predation control had previously sustained severe wounds, precluding them from hunting normally (Hoogesteijn *et al.* 1993),

although the condition of jaguars not killed could not be confirmed. In our study, all radio-collared jaguars were in excellent physical condition at the time of capture (Cavalcanti 2008), as were those documented by Schaller and Crawshaw (1980) and Hopkins (1989). The oldest individual radio-tracked (a male estimated to be >11 years old) had two missing canines (a broken lower canine on his first capture and a further broken upper canine on his second capture) and killed white-lipped peccaries, feral hogs, and marsh deer at a similar rate (7.1 ± 5.6 [SD] days between kills) as all the other radio-tracked jaguars (no significant difference between the jaguar kill rates; Cavalcanti 2008).

Perceptions about depredation and persecution

Depredation problems caused by jaguars have been reported by 82% of the landowners in the northern Pantanal (Zimmermann *et al.* 2005a; Marchini and Macdonald, in preparation-a). Not surprisingly, jaguars were considered the most detrimental species to human livelihoods by 73% of 110 ranchers and ranch hands interviewed in both the southern and northern Pantanal (Marchini 2003). Reported losses to jaguars ranged from 0% to 11% of their livestock holdings, with greater proportional losses among smaller ranches and smaller herds ($r = -0.590$ and -0.716 , both $P < 0.001$; Zimmermann *et al.* 2005a) with losses averaging between 2.1% (Marchini and Macdonald, in preparation-a) and 2.3% (Zimmermann *et al.* 2005a) of their livestock holdings. In absolute terms, the greatest reported loss was 80 calves in 1 year from a herd of 2000 head on a 13,200 ha ranch. Given the average price of a calf in the region (approximately US\$228 in 2008), this case translated into a monetary loss of US\$18,240 (Marchini and Macdonald in preparation-a). Over one-third of the respondents (38%) ranked jaguars as a greater problem affecting their income from cattle than floods, droughts, rustling, and disease (Zimmermann *et al.* 2005a).

Most ranchers (62%) reported that jaguar attacks show no seasonal pattern (Zimmermann *et al.* 2005a). As for variation between years, 24% of the respondents believed the frequency of attacks within

their ranches was increasing, 35% believed it was declining, and 41% stated it was not changing (Marchini and Macdonald, in preparation-a). Most ranchers (72%) believed that jaguars varied in their dietary preferences and thus believed that 'problem jaguars' were the ones killing cattle (Marchini and Macdonald, in preparation-a).

These findings suggest that perceptions of jaguar depredation might sometimes exceed reality, as ecological studies addressing jaguar depredation in the Pantanal and elsewhere revealed lower losses of livestock holdings (0.83% in two ranches of northern Pantanal, 0.3% in one ranch of southern Pantanal, and 1.26% in southern Amazonia; Dalponte 2002; Azevedo and Murray 2007b; Michalski *et al.* 2006a, respectively). However, when predation rates were estimated from GPS-collared jaguars (Cavalcanti 2008), the ranch foreman reported the ranch lost on average 70 head of livestock out of 6000 head annually to jaguar predation (1.2% of livestock holdings). During a dry year (2002), a jaguar killed an average of 2.1 calves/month and 0.6 adult cows/month, for a total of 2.7 head of cattle/month. Extrapolating this kill rate to half (not all jaguars had equal access to cattle), the estimated resident (80%) population of jaguars on the ranch (6.7 jaguars/100 km²; Soisalo and Cavalcanti 2006) would generate an estimated loss of about 390 head of livestock. Conversely, during wet years (2003), jaguars killed an average of 0.5 calves/month and 0.3 adult cows/month, for a total kill rate of 0.8 head of cattle/month. Again extrapolating to half, the resident jaguar population on the ranch generated an estimated 118 head of livestock lost. During a wet year (2003), the perceived losses (70 head; 1.2% of cattle) and the estimated losses from jaguar predation rates (118 head; 1.9% of cattle) were similar. Conversely, during a dry year (2002), predation rates indicated that over five times more cattle were lost (390 head; 6.5% of cattle) to jaguar predation than the ranch foreman perceived (70 head). Therefore, the level of rainfall influences the number of cattle lost annually by determining the access cattle have to the landscape and the number of jaguars to which they are exposed, in addition to increasing their vulnerability due to poor body condition. In addition, we generally found that cattle killed by the radio-collared jaguars were found by the ranch hands only rarely and unreported losses are likely higher

than previously believed. Ranch hands easily found cattle kills in open fields and pastures, while missing most kills in the dense cover of shrublands and forests.

We emphasize that these extrapolations of predation rates are from only one study and may not be representative of all ranches in the Pantanal. However, it does raise the issue that accurate and unbiased documentation of jaguar kill rates on livestock and native prey are needed, to lend credibility to claims on both sides of the argument regarding losses sustained by livestock operations. In a study examining wolf (*Canis lupus*) predation on livestock in central Idaho, USA, researchers reported that ranchers found only one in eight of the actual kills documented (Oakleaf *et al.* 2003). During the years of wolf reintroduction into the United States, government personnel consistently agreed that a rapid response time and accurate documentation of actual losses were critical to any compensation programme proposed for ranchers, and lack of data can often lead to heated debate about the actual level of losses sustained by a ranching operation. Some ranchers were very diligent in keeping track of losses, while others were less accurate and blamed predators for more losses than actually occurred.

In addition to the perceptions about the level of jaguar depredation on livestock, other beliefs and perceptions about jaguars and jaguar hunting may be relevant in dealing with conflicts between ranchers and jaguars. Many ranchers (30%) held the perception that jaguar abundance was currently increasing (4% perceived it as decreasing; Marchini 2003). In the Pantanal subregion of Cáceres, 80% believed jaguar abundance was increasing and there was a widespread perception that jaguar numbers were now abnormally, and unbearably, high (Marchini and Macdonald, in preparation-a).

A few ranchers (15%) in the subregion of Poconé believed that jaguars caused cattle mortality even without preying on them (Marchini and Macdonald, in preparation-a). The rationale was that jaguars scared cattle out of the 'capões' (dry forest patches where cattle find refuge during floods), from which the cattle then ran to flooded areas, where they drowned or got stuck in the mud and starved to death. This belief in 'indirect predator-induced mortality' of livestock needs further investigation.

Some people perceived jaguars as a threat to human safety. Many respondents (53%) believed

that jaguars attacked people even when not provoked (Marchini and Macdonald, in preparation-a). A rural school in Cáceres closed its doors in 2008 because the pupils refused to attend classes after several sightings of jaguars in the vicinity. This episode occurred prior to an incident on 24 June 2008 when a young fisherman was killed by a jaguar while sleeping in his tent on a riverbank of the Paraguay River, in the subregion of Cáceres. This was the first officially documented, unprovoked, fatal attack of a jaguar on a human in Brazil, and was widely covered by the national media. Prior to this incident, attacks were almost invariably associated with hunting situations in which the jaguar was cornered or injured. Jaguars are also known to attack in order to defend their cubs or the carcass upon which they are feeding. The impact of the above event on people's perceptions of the risk that jaguars pose to human safety is currently being assessed.

Many ranchers unashamedly admit that killing jaguars is socially acceptable. Only 15% of the respondents believed their neighbours or family would disapprove of them killing jaguars (Marchini and Macdonald, in preparation-a). For many, killing jaguars is considered one of the traditions of the Pantaneiro culture. Additionally, there is the general view that all aspects of the Pantaneiro culture should be cherished and preserved. Indeed, a prevailing opinion is that hunting jaguars is an act of bravery and a test of dexterity among cowboys. Shooting a jaguar enhances a cowboy's reputation. Even when ranch owners have specifically banned jaguar hunting, some ranch hands may continue to kill jaguars (S. Cavalcanti, personal observation).

The extent to which a rancher perceives the difficulty of killing a problem jaguar may affect the likelihood of actually pursuing this option. The general approach is to use dogs to find and pursue the jaguar. Either the jaguar climbs a tree or turns at bay on the ground, whereupon the hunters arrive and kill it. In the Pantanal, hiring a professional hunter who owns a pack of trained dogs can be relatively easy and affordable (sometimes a cow is offered in exchange for the service), but in other regions, the difficulty and cost of hiring a hunter may discourage small ranchers from killing jaguars. Several small landowners on the Amazon agricultural frontier, for instance, told us they had never killed a jaguar but

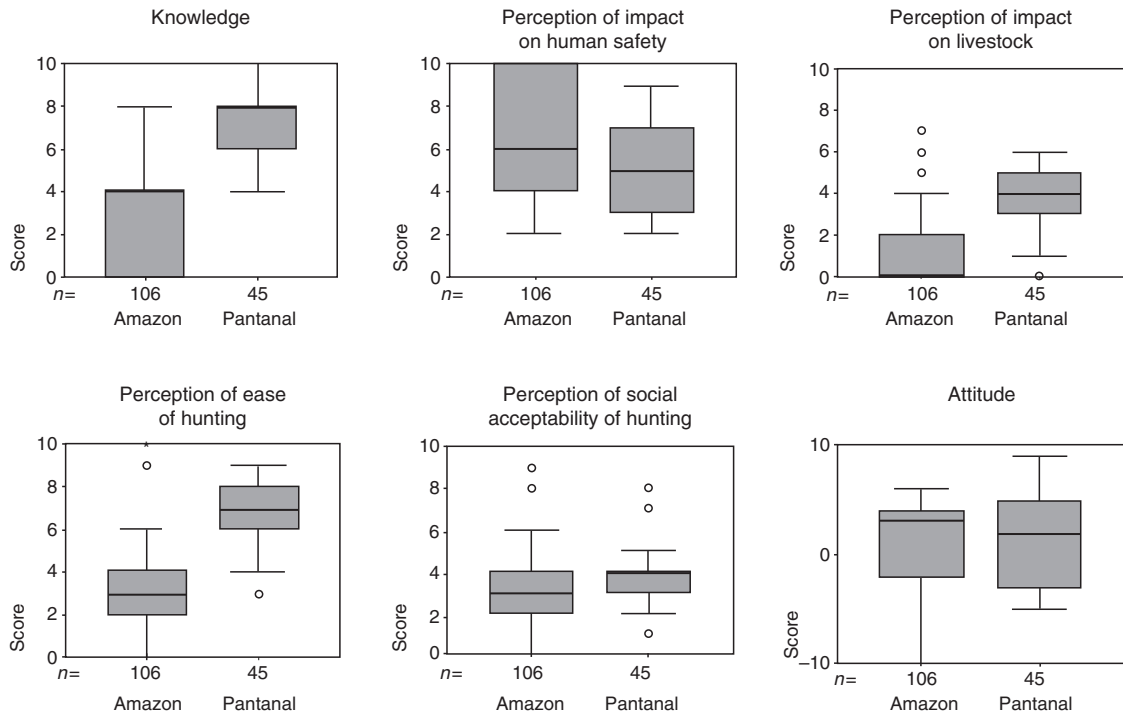


Figure 17.7 Graphs showing the measurement scales, distribution of average score values, and differences between Amazon and Pantanal. The box indicates the median, 25% and 75% quartiles, and whiskers are the largest values that are not outliers, while circles mark outliers.

would have killed the cat if they had had the capacity to do so (Marchini and Macdonald, in preparation-a).

Surprisingly, jaguars also elicit positive feelings among ranchers. All our respondents considered the jaguar a 'beautiful' or 'very beautiful' animal (Marchini and Macdonald, in preparation-a), and 16% would choose the species to be the symbol of the Pantanal (only the jabiru stork, *Jabyru mycteno* the official symbol of the region, ranks higher; Marchini 2003). Although we met ranchers who confessed hatred of jaguars, irrespective of their behaviour, the average attitude score value of ranchers in the region, for questions assessing an individual's like or dislike for jaguars (e.g. 'How would you feel if all jaguars disappeared?') and unfavourability or favourability towards jaguar persecution (e.g. 'Would killing any jaguar that shows up in your property this year improve your livelihood?'), was positive (Fig. 17.7; Marchini and Macdonald, in preparation-a).

Finally, the economic decline in the region may exacerbate the conflict between ranchers and jaguars.

In recent decades, growing competition within the cattle industry, higher taxes, and generational land splitting has made cattle ranching less profitable in the Pantanal (Swarts 2000). Indeed, 95% of the ranchers believed their economic situation is worse now than in the past (Marchini and Macdonald, in preparation-a). A decline in the profit margin from cattle ranching may decrease their tolerance of jaguar depredation on their cattle. The growth of ecotourism in the region has brought the hope of better days for some ranchers (and conservationists as well), although ecotourism alone seems unlikely to be a universal solution.

Variation in perceptions and its determinants

In order to understand how and why the above perceptions vary, we examined correlations between

perceptions and socio-economic and demographic variables (Table 17.2). Details of these analyses are in Marchini and Macdonald (in preparation-a).

The perceived impact of jaguars on livestock, which was measured using questions about recent and past depredation events, the magnitude of the losses (from none to very large) on his ranch, as well as neighbouring and relatives' ranches, and the current trends in the jaguar depredation problem (decreasing, unchanged, and increasing), was positively correlated with the perception of increasing jaguar abundance ($r = 0.41$, $P < 0.02$) and declining economic situation ($r = 0.47$, $P < 0.04$). There was also a negative correlation between their attitude towards jaguars ($r = -0.61$, $P < 0.0001$) and the number of years attending school ($r = -0.49$, $P < 0.0001$): ranchers had stronger negative attitudes towards jaguars in relation to fewer years in school (education varied greatly among respondents, from 33% being illiterate to 22% with higher education). Attitudes towards jaguars was also negatively correlated with the respondents' perception of the deterioration in the economic situation ($r = -0.57$, $P < 0.04$) and positively correlated with years in school ($r = 0.36$, $P < 0.0001$), which was negatively correlated with age ($r = -0.50$, $P < 0.001$). The rationale for using different questions to assess the perceptions of the impacts on livestock is that a rancher's evaluation of these impacts is not based solely on his recent losses to jaguars. Different ranchers, depending on their background and socio-economic situation, see the same loss as small or large. The perceived impacts of jaguars on human safety were measured with questions regarding (a) the potential for unprovoked attacks on humans by jaguars, as well as any perceived man-eating habits among jaguars; (b) first- or second-hand reports of jaguar attacks on people (fatal or not); and (c) the magnitude of threats to human safety posed by jaguars and the innate fear of jaguars (none to very large). All of these perceptions were positively correlated, with a perceived increase in jaguar abundance ($r = 0.45$, $P < 0.02$) and negatively correlated with the respondent's knowledge of jaguar ecology and depredation problems ($r = -0.53$, $P < 0.0001$). In summary, if a person's perception of the jaguars' impact on livestock and human safety determines retaliatory persecution, then perceptions of increas-

ing jaguar abundance and declining economic situation, attitudes towards jaguars, years in school, age and knowledge of jaguar ecology, and depredation problems may all play a role in conflicts between humans and jaguars in the Pantanal.

Some differences between the perceptions in the Pantanal versus the Amazonia region are relevant to this discussion (Fig. 17.7; Marchini and Macdonald, in preparation-a). The perception of the jaguars' impact on livestock was stronger in the Pantanal than in the Amazon ($t = -9.966$, $P < 0.0001$, d.f. = 149), whereas the perceived threat to human safety was higher in the Amazon than in the Pantanal ($t = 2.919$, $P = 0.004$, d.f. = 149). Even though attitude to jaguars was similar in the two regions ($t = -1.112$, $P = 0.268$, d.f. = 149), in the Pantanal, attitude was correlated with the perceived impact on livestock (see above), whereas in the Amazon, it was correlated with the perceived impact on human safety ($r = -0.39$, $P < 0.01$). We also found differences in the perception of social acceptability of jaguar hunting; assessed by whether the respondent felt his family and neighbours would approve or disapprove if he killed jaguars. The acceptability of killing jaguars was higher in the Pantanal than in Amazonia ($t = -2.962$, $P = 0.004$, d.f. = 149) and so was the perceived ease of persecuting jaguars ($t = -13.044$, $P < 0.0001$, d.f. = 149). In addition, people in the Pantanal were more knowledgeable about jaguars and depredation problems than were people on the Amazon frontier ($t = -7.684$, $P < 0.0001$, d.f. = 149). For instance, whereas 89% of the respondents in the Pantanal could tell the difference between jaguar and puma tracks, only 7% of the respondents in the Amazon were correct in their identification skills.

From perceptions to persecution

From a conservation standpoint, what ultimately matters in conflicts between people and jaguars is the level of persecution and its impact on a carnivore population. To investigate the relationship between perceptions, attitudes, and persecution, we used a hierarchical cognitive model based on the correlations mentioned above and adapted from the 'Theory of Planned Behaviour' (TPB, Ajzen 1985). This is an influential theory in social psychology attempting to

Table 17.2 Zero-order correlations between perception, knowledge, and attitude scores, and demographic and socio-economic variables in the Pantanal.

No.	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	-.50**	1									
3	.28	.08	1								
4	-.15	-.28	-.17	1							
5	.05	-.12	-.08	.18	1						
6	.43	-.25	.38	.08	.26	1					
7	-.08	.27	-.11	-.53**	.45*	.10	1				
8	.18	-.49**	-.14	.16	.41**	.47**	.19	1			
9	-.14	.09	-.12	.22	.13	-.11	.13	-.15	1		
10	-.10	.19	-.04	-.25	.39	.29	.07	-.18	-.07	1	
11	-.16	.36*	.14	-.06	-.33	-.57**	-.04	-.61**	.04	-.05	1

** Correlation is significant at the 0.01 level (two-tailed).

* Correlation is significant at the 0.05 level (two-tailed).

predict a person's behaviour (see also Macdonald *et al.*, Chapter 29, this volume). In the vocabulary of the TPB, a person's behaviour is explained by behavioural intention, which is preceded by 'attitude towards the behaviour'. Intention also depends upon 'subjective norms', which is a person's perception of the social acceptability or desirability of the action in question, and 'perceived behavioural control', which is the actor's perception of the ease or difficulty of performing the specific action. Background factors such as age, education, wealth, occupation, culture, and knowledge may influence these attitudes and perceptions, but are not incorporated in the causal model (Ajzen 1985). In our model, jaguar persecution is represented by the intention to persecute jaguars, which is preceded by attitude towards persecution, norms regarding this behaviour, and perceived behavioural control over it. Given the central importance of the perceptions of jaguars' impact on livestock and on human safety in the conflicts between people and jaguars, we expanded our TPB model to address explicitly those perceptions as potential determinants of attitude towards persecution (Fig. 17.8). This approach allowed us to assess the relative importance of the different components of the causal chain of jaguar persecution so that more effective interventions could be devised to decrease persecution.

Marchini and Macdonald (in preparation-b) assessed the intention to persecute jaguars via the question: 'Would you kill any jaguar that shows up in your property?' The answer to this question was expressed in the form of a dichotomy: a person either

intended to persecute or not. Evidence of recent persecution of jaguars was found in 27 ranches (8 in the Pantanal and 19 in Amazonia), which facilitated validation of this measurement. Most (81%) of the people who had killed jaguars in the previous 2 years said that they intended to persecute any jaguar that showed up on their ranch, whereas 20% of the people who had not killed any jaguar expressed the intention to persecute ($\chi^2 = 35.301$, d.f. = 1, $P < 0.001$). This seeming association between declared intentions and actions strengthens our conclusion that we should take seriously the statements other ranchers made to us about their intentions to kill jaguars. Almost 60% of the landowners in the Pantanal declared their intention to kill any jaguar that showed up on their land, whereas in the Amazon about 20% of the landowners did so.

Regression analysis revealed that attitudes and subjective norms significantly explained the variation in the intention to persecute jaguars in the Pantanal: more favourable attitudes towards jaguar persecution and a greater perception of the social acceptability of jaguar hunting were associated with a greater intention to kill jaguars ($\beta = -0.259$, $P = 0.01$ and $\beta = 0.497$, $P = 0.024$, respectively; $-2\log$ likelihood = 46.722). Several ranchers in Marchini and Macdonald's sample (in preparation-b) also expressed the view that killing jaguars was appropriate on the grounds that it was a tradition passed from generation to generation. The important influence of these social norms was unsurprising considering that many ranchers in northern Pantanal were

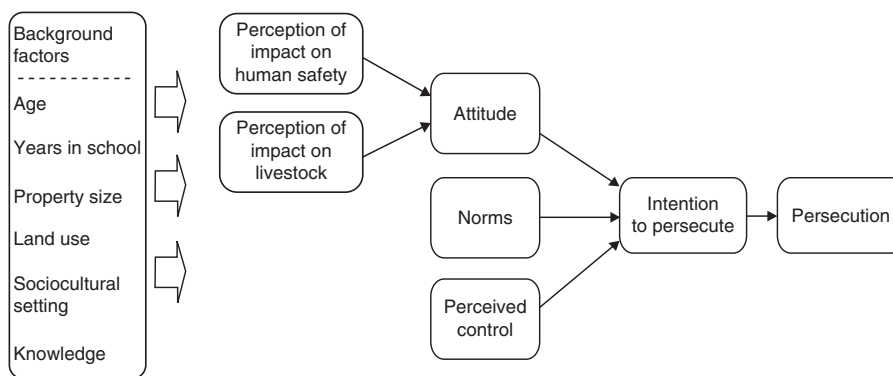


Figure 17.8 Hierarchical cognitive model of jaguar persecution adapted from the Theory of Planned Behaviour (Ajzen 1985).

interrelated, with a network of family bonds linking ranches. Attitude, in turn, was correlated with the perceived impact of jaguars on livestock (R^2 adjusted = 0.364, $F = 26.138$, $P < 0.0001$). Cattle ranching is an icon of the Pantaneiro culture. The few traditional families that together own a substantial portion of the lands in the northern Pantanal have been raising cattle in the region for generations, and this has been the only viable economic activity. The economic and cultural centrality of cattle ranching in the region doubtless affects the high correlation between perceptions of the jaguars' impact on livestock and the attitudes towards persecution. Although cattle ranching in the Pantanal is generally undertaken at such a large scale that the loss of a few cattle is unlikely to seriously impact the ranchers' livelihoods, for the majority of ranchers, such losses are unacceptable and may be higher than actually realized given detection rates of kills.

In contrast, in the Amazon, the intention to persecute jaguars was significantly explained by attitude to persecution and perceived ease or difficulty of persecuting ($\beta = -0.481$, $P < 0.0001$ and $\beta = 0.663$, $P = 0.011$, respectively; $-2\log$ likelihood = 66.831). Indeed, a significant proportion of the landowners, and particularly those with smaller properties, favoured the idea of killing jaguars, but did not intend to engage in this activity because they believed that they lacked the means (or were not brave enough, as they told us) to do so. In the Amazon sample, the perceived social acceptability or desirability of persecution did not significantly affect the intention to persecute jaguars, which might reflect the reality that in this frontier area people typically have little interaction, or shared background, with their neighbours. However, their attitudes were heavily associated with the perceived risk of jaguars on human safety (R^2 adjusted = 0.488, $F = 18.385$, $P < 0.0001$). A fear of jaguars is common among the frontiersmen, who were largely immigrants with little experience of jaguars and the forest.

Finding solutions for the future of jaguar-human coexistence

Direct persecution of jaguars by people, combined with the hunting of prey used by jaguars, is the most

significant threat to the long-term survival of jaguars throughout their range (Sanderson *et al.* 2002b; Zeller 2007). Most persecution is directed at jaguars living near or within areas of livestock raising. Jaguars kill livestock and this creates a conflict with ranchers from an economic perspective. Several aspects of jaguar ecology and behaviour elucidated by our studies have direct implications for this economic aspect of jaguar conservation. The obvious, and traditional, response has been attempting to curtail jaguar depredation on livestock through preventive measures. A radical, but evidence-based, alternative would be for all stakeholders to recognize the reality that cattle are routinely a component of jaguar diet in the region. Under the Biodiversity Impacts Compensation Scheme (BICS) model proposed by Macdonald (2000; elaborated with respect to carnivore conflict by Macdonald and Sillero-Zubiri 2004b), the approach would be to refine management interventions to reduce negative impacts (stock losses), and then find other mechanisms to offset irreducible damage; in this case, alternative mitigation measures to make the residual stock losses to jaguars bearable. Additionally, while kills of domestic stock may be related to a lack of natural prey (Saberwal *et al.* 1994; Vos 2000), in that predators have no alternative choice of food, this chicken-and-egg logic can be reversed insofar as domestic stock adds to the carrying capacity of the environment for predators. Schaller (1972) found that the more abundant a preferred species was, the more likely it was to fall prey to lions. By extension, in the Pantanal, cattle are both the most abundant and the most vulnerable prey, so some level of jaguar predation is an inevitable and a natural part of ranching, like drought or soil fertility (Soisalo and Cavalcanti 2006). By analogy, there are limits to the feasibility of mitigating such environmental effects on agriculture, and limits to what society deems an acceptable cost of environmental intervention. For example, the latter is clearly illustrated in Europe by payments to farmers for custody of nature under the Common Agricultural Policy (Dutton *et al.* 2008). To the extent that irreducible damage by jaguars to cattle ranchers must be offset (rather than tolerated as an inevitable consequence of farming in jaguar country), solutions might lie in financial instruments such as tax benefits, favourable credits, or a regional increase in beef prices. The significance of livestock losses to jaguars will be

proportionally diminished by ranchers improving other aspects of rudimentary herd husbandry that currently account for more losses than does jaguar predation (Hoogesteijn *et al.* 1993). That said, the quest for efficiency will eventually bring the farmer into head-on collision with those losses to jaguars that are unavoidable, and society will need to decide who is to bear these costs.

Recently, there has been an effort in the Pantanal to alleviate jaguar–livestock conflict in the form of a compensation programme (Silveira *et al.* 2006). Such programmes have been explored worldwide (Saberwal *et al.* 1994; Wagner *et al.* 1997; Vos 2000; Naughton-Treves *et al.* 2003; Swenson and Andrén 2005) but their effectiveness is debated (Nyhus *et al.* 2003, 2005; Bulte and Rondeau 2005; Maclennan *et al.*, 2009). Unverifiable losses, fraudulent claims, overly bureaucratic procedures and associated time lags in payment, payments below market values, lack of sustainable funding, high administrative costs, and moral hazard are some of the drawbacks associated with compensation programmes (Bulte and Rondeau 2005; Nyhus *et al.* 2005; Zabel and Holm-Müller 2008). Ideally, such schemes would be closely monitored, but in the Pantanal, this is challenging because retaliatory, illegal killing of jaguars is often clandestine.

An alternative to compensation involves ‘performance payments’ (Nyhus *et al.* 2005; Zabel and Holm-Müller 2008). By analogy with agri-environment schemes elsewhere, payments would be conditional on some measure of effective jaguar conservation in an area (Ferraro and Kiss 2002; Zabel and Holm-Müller 2008). As with all environmental payments (and compensation schemes), it would be essential to have effective monitoring, robust regulation, and care to avoid unintended consequences.

However, the results of our studies demonstrated that the problem goes beyond the economics and into the realms of culture—depredation on stock and retributive killing turn out to be more loosely linked than is often supposed. Although prejudices against jaguars are deeply ingrained within the culture of cattle ranching, attitudes can change over generations. Wolves were eradicated from the Rocky Mountain region of the United States by the 1930s, but are now making a dramatic comeback after reintroduction efforts in 1995. It may have taken decades, but policies towards wolves slowly changed

over time as ecological studies and social attitudes reflected an increasing appreciation for the role that top predators play in ecosystem dynamics. In the case of the Pantanal, given that cowboys are ultimately the ones whose behaviour will directly impact jaguar conservation, one priority would be to make them stakeholders in jaguar conservation, and this could be a potent ingredient of any performance-related scheme. Examples from the Amazon and Africa illustrate the potential of community-based resource management in wildlife conservation (Lewis *et al.* 1990; Castello 2004; Frost and Bond 2008). It will require ingenuity to formulate, and then regulate, a scheme that delivers benefits to both landowners and local communities from successful custody of ‘their’ jaguars. For example, mechanisms might be sought to channel payments both to landowners and into wider community benefits (e.g. education, health, and economic development) to encourage, ideally in ways that even foster, peer pressure against those persons killing jaguars.

Our synthesis reveals that while jaguars do indeed kill livestock in the Pantanal, this is not the only, nor perhaps even the most important reason, why people kill jaguars. Therefore, in many cases, jaguar conservation may need to be approached in many different ways. As described here, in our case studies from the Pantanal and the Amazon, the motivations for killing jaguars include not only traditions and social rewards, but also the fear and misconceptions of the threat that jaguars pose to humans, the social incentives for persecution, as well as the economic viability of ranching. These insights may lead us towards approaches to decrease persecution that rely on gradual changes in the values, attitudes, and social norms concerning jaguars and jaguar persecution and that are tailored for the specific region. For example, whereas in the Pantanal communication campaigns to influence the social norms concerning jaguar hunting may significantly contribute to decrease in persecution, in the Amazon education to increase knowledge and improve perceptions about jaguars’ threat to human safety might be more effective. Although the Pantanal is very important for jaguar conservation in the long term (Sanderson *et al.* 2002b), it would be unwise to generalize too readily from this particular situation

to other parts of the jaguar's range. Nonetheless, conditions in the Pantanal are similar to those in, for example, the tropical-wet savannahs of the Venezuelan Llanos and the Bolivian Beni, so there is scope for an international analysis of cross-regional patterns in jaguar conflict (Zimmermann and Macdonald, in preparation).

Unquestionably, practical conservation must be underpinned by sound science. The illuminating power of data to allow for informed discussions and dispel misconceptions is illustrated by the findings we report on jaguar predatory behaviour in the Pantanal. However, the tensions between people and wildlife are so complicated that while ecological science is necessary as a foundation for solutions, it is not sufficient to deliver them. Drawing on methodologies from the social sciences, we have shown that the link between jaguar depredation on cattle and retaliatory persecution is only part of the story. To change peoples' actions will thus require a more far-reaching involvement that examines and understands their perceptions and traditions.

Acknowledgements

The Pantanal Jaguar Project was supported by the Wildlife Conservation Society; the U.S. Department of Agriculture; National Wildlife Research Centre at Utah State University, Logan, Utah; the National Scientific and Technological Development Council in Brazil; the Conservation, Food, and Health Foundation; the Mamirauá Civil Society; and Brazilian Foundation for Sustainable Development. The People and Jaguars Coexistence Project, in collaboration with the Wildlife Conservation Research Unit (Oxford University), has been supported by Cristalino Ecological Foundation, Instituto HSBC Solidariedade, Anglo American Brazil, Rainforest Concern, Cleveland Metroparks Zoo, North of England Zoological Society (Chester Zoo), Woodland Park Zoo, O Boticário Foundation, Fauna & Flora International, and Kevin Duncan. The global survey of human–jaguar conflicts project is funded by North of England Zoological Society (Chester Zoo) in collaboration with Wildlife Conservation Research Unit (Oxford University). Input from Paul Sparks.

Appendix 6:

Contemporary views of human-carnivore conflicts on wild rangelands.

Zimmermann, A., Baker, N., Inskip, C. Linnell, J.D.C., Marchini, S., Odden J., Rasmussen G. & Treves, A. (2010) Contemporary views of human-carnivore conflicts on wild rangelands. In: *Wild Rangelands: Conserving Wildlife While Maintaining Livestock in Semi-Arid Ecosystems*. Editors: J. du Toit, R. Kock & J.C. Deutsch. Wiley-Blackwell, UK. 129-151.

Contemporary Views of Human–Carnivore Conflicts on Wild Rangelands

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Introduction

Conflicts between wildlife and people pose a challenge of increasing concern to conservation scientists (Woodroffe et al. 2005). Human–wildlife conflict arises when the behaviour of wild animal species poses a direct and recurring threat to the livelihood or safety of a community and, in response, persecution of the species ensues. Persecution – the persistent killing, chasing or other harassment of a species – in the context of human–wildlife conflict differs from hunting in that the hunter seeks a product (meat, trophy, sport), while in conflict the aim is to menace or eradicate the animal or species. Retaliation

Wild Rangelands: Conserving Wildlife While Maintaining Livestock in Semi-Arid Ecosystems,
1st edition. Edited by J.T. du Toit, R. Kock, and J.C. Deutsch.
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against wildlife occurs in numerous scenarios, including when commercial ranchers and subsistence pastoralists lose livestock to predation, farmers lose crops to wildlife, hunters and carnivores compete over game species or ordinary villagers live in fear of animal attacks, as can happen for predatory, territorial, or defensive reasons (Conover 2002). Populations of many species, especially large carnivores, have declined significantly as a result of such conflict.

Terrestrial, large-bodied carnivore families are particularly susceptible to conflict with people because these animals require the spaces and resources compromised by increasing human dominance on landscapes. Conflict often occurs where natural prey is depleted and livestock provide a good alternative food source, or where habitat is disturbed, such as on the edges of protected areas where the likelihood of animal–human encounters increases, creating population sinks (Woodroffe & Ginsberg 1998). Livestock management practices (e.g. level of protection, general condition of stock) also affect conflict (Hoogesteijn 2003; Ogada et al. 2003). An individual predator's condition, including health, age and territory, has also been correlated with depredation, although not proven to predispose carnivores to prey on livestock (cf. Rabinowitz 1986; Linnell et al. 1999; Miquelle et al. 1999; Wydeven et al. 2004).

The order Carnivora contains 11 families and around 260 species (Macdonald 2001). Human–wildlife conflicts tend to involve cats (Felidae), dogs (Canidae), bears (Ursidae) and hyaenas (Hyaenidae). It is not widely known or documented that conflicts typically involve smaller-bodied species such as raccoons (Procyonidae), weasels (Mustelidae), skunks (Mephitidae), civets (Viverridae) or mongooses (Herpestidae); the exception is the wolverine, a predator of sheep and semi-domestic reindeer in northern Eurasia. Even within the cat, dog, bear and hyaena families, certain species are more prone than others to conflicts with people. Likelihood of conflict appears to be a function of carnivores' body size and proximity to human-dominated landscapes.

Understanding the dynamics of a human–wildlife conflict is challenging in itself; resolving conflict is even more difficult. For local communities, the economic impacts of coexistence, as well as perceptions and attitudes, influence tolerance of carnivores (Woodroffe & Ginsberg 1998; Sillero-Zubiri & Laurenson 2001; Hussain 2003; Treves & Naughton-Treves 2005; Zimmermann et al. 2005). This plays a critical role in conservation, which requires positive attitudes and participation on the part of involved communities. Conflict resolution requires a balance of practical solutions, outreach and

the best available information on both the ecology of the species concerned and the social psychology of the people affected.

Human–carnivore conflicts occur in many different habitats, but rangelands have always been particularly prone to conflicts, as this is often where carnivores and their prey, and people and their livestock occur together in the same space and are very likely to encounter one another. In some areas, natural prey species are reduced in numbers, in others domestic livestock are semi-free-ranging and poorly protected and thereby present a much easier catch for the carnivore than the quicker and more alert wild ungulate. In most cases it appears to be a combination of these factors that leads carnivores into depredation and resentful ranchers or pastoralists into retaliatory or preventative persecution. In some rangelands the predators are persecuted to the point of near-eradication, which presents ethical as well as ecological issues. Carnivores are fundamentally important top-down regulators of herbivore communities and so their removal from an ecosystem to which they are adapted has wide implications for ecosystem structure and function (Treves & Karanth 2003).

For rangelands already threatened by agricultural conversion, overgrazing, invasive species and more, human–wildlife conflicts add yet another dimension of complexity to conservation (in Foreword by Sinclair and Schaller). In this chapter, we aim to illustrate some of the diverse pressures, responses and dynamics shaping this issue. The six case studies we highlight from around the globe demonstrate the range of regions and socio-economic conditions in which conflicts occur.

Hunter versus predator: wolves in North America

Thirty-two years ago, the last of the grey wolves (*Canis lupus*) in the lower 48 states of the United States were declared endangered by the Federal Government. They had been eliminated from all but a tiny area around Lake Superior because they competed with humans for livestock and game. Today, the western Great Lakes region of the United States holds around 3500 wolves across human-transformed areas of Minnesota (MN), Wisconsin (WI) and Michigan (MI) (USFWS 2007). In 2007, the US government proposed removing federal endangered/threatened species protections for this grey wolf population. The scenario above is not entirely rosy. Returning the

management of wolves to the range states raises concerns about renewed extirpation campaigns. For example, proposals to hunt wolves in Wisconsin are alarming wolf preservationists. Transfer of authority is more than a shift in institutional responsibility for wolf management; it signals a change in emphasis from restoration to coexistence. Yet wolves continue to attack domestic animals and the definition of coexistence by the many interest groups differ.

In the western Great Lakes region, wolf predation on domestic animals – mainly beef cattle and hunting dogs – kept pace with population growth through 2000 (Fritts et al. 1992; Treves et al. 2002). But such predation incidents may have begun to outpace wolf population increase in the past 7 years. Domestic animal depredation and other real and perceived conflicts generate opposition to wolf conservation, especially in rural areas with high proportions of livestock producers and hunters (Naughton-Treves et al. 2003; Treves et al. 2007). Opponents of wolf recovery may retaliate illicitly. More than half of Wisconsin's adult wolf mortality is caused by people, much of it, apparently, intentional (Wydeven et al. 2001). More commonly, opponents call for stricter control of suspected problem packs and for regulated public hunting of wolves.

Neither selective lethal control nor public hunting has a strong record of effectiveness in preventing future conflicts or eliminating culprits selectively (Treves & Naughton-Treves 2005). Wolf predation on livestock continues despite approximately 20 years of legal, lethal control in MN and of several years in WI and MI, as well as continuous illicit killing (Wydeven et al. 2001). Yet perceptions have changed about problem carnivores.

The traditional view that any carnivore will kill livestock if given the opportunity has given way in the face of scientific evidence (Treves et al. 2002; Wydeven et al. 2004). An alternative explanation is that problem individuals arise spontaneously, so large carnivore populations will always have problem individuals. Opinions differ about the genesis of such problem carnivores. Some maintain that exposure to livestock carcasses, garbage or other human food sources leads to problem behaviours (Andelt & Gipson 1979; Jorgensen 1979). Another conjecture is that non-culprit carnivores are being killed at rates too high to exert efficient selection against problem individuals, so we see no diminution of conflicts. A recent review found high error rates in lethal control operations on wolves, bears and coyotes (Treves & Naughton-Treves 2005). In sum, for various reasons, we should not expect a decline in livestock predation by wolves or any other large carnivore in the western Great

Lakes region until managers and stakeholders act in a systematic manner to understand and prevent factors that may underlie conflicts.

Even if livestock predation by wolves could be reduced to a minimum, hunters might still object, in force, to the presence of this competitor (Hammill 2005). Hunters may find less game in their habitual shooting grounds. Preventing a large carnivore from pursuing its wild prey is more complex than preventing predation on livestock (Treves & Naughton-Treves 2005). Hence interventions to reduce conflicts between hunters and wolves will take ingenuity and changes in human behaviour. Some groups address the issue through efforts at hunter education, while others advocate a change in status of wolves from protected species to game species. Numerous challenges lie ahead before wolves are subject to regulated public hunting, but in the Lake Superior Region with its strong, popular tradition of hunting, this intervention may gather momentum now that states have the authority.

Finally, when one discusses the future of wolf recovery, managers often lower their voices and allude to drastic changes if a wild wolf attacks a human. Other regions' experiences warn us to prepare for such an attack (Rajpurohit 1998; Linnell & Bjerke 2002). It could precipitate a dramatic change in wolf management policy. Swift justice would be demanded and the response might not be limited to the suspected culprit or its pack. Pre-empting disproportional retaliation should be an explicit management objective. In addition to a better understanding of the genesis and behaviour of problem carnivores, we need greater effort and support for social scientific research aimed at understanding tolerance, anthropogenic mortality and the events that precipitate political backlashes against large carnivores.

Developing a risk assessment protocol: wild dogs in Africa

Colonialism in Africa ensured that the traditionally negative European perception of the wolf was transferred to the African wild dog (*Lycaon pictus*) wherever agriculture was established. Wild dogs were declared vermin and a bounty put on their heads in both ranchlands and national parks (Bere 1956; Childes 1988). Justification for this was self-defence, preservation of game populations and protection of domestic stock, though rarely was the extent of damage verified or quantified. In Zimbabwe, ranchers and government agencies systematically persecuted wild dogs from 1904 to 1988, by which

time populations of wild dogs were at risk of being extirpated. The perception persisted, however, of wild dogs as voracious cattle- and game-killers partly based on rare occurrences of predation on livestock. In the early 1990s, a spate of incidents in the cattle-ranching region of Nyamandlovu, Zimbabwe revived the conflict between humans and wild dogs, but presented the opportunity to develop a better understanding of the real rather than the perceived threat and a new approach for alleviating human–wild dog conflict. The primary objective in developing a conflict protocol was ensuring a viable number of dogs for maintaining genetic diversity through natural dispersal (Fuller et al. 1992) and active meta-population management (Mills et al. 1998).

A critical first step in reducing negative perceptions of wild dogs was discerning and publicizing the actual extent to which they posed a threat to livestock. To accomplish this, the researchers aimed to determine the accuracy of claims of wild dogs killing cattle in the Nyamandlovu region. Participatory methods were used instead of postal questionnaires to reduce bias in the responses from ranchers (Rasmussen 1999). Interviews also establish personal contact with people affected by stock depredation and demonstrate the willingness of conservation practitioners to listen, which is an important step in ameliorating conflict. Following on from this ground work, there was a three-part risk assessment phase. First, the risk of a pack being extirpated was estimated from criteria such as residence status, home-range configuration, denning status, habituation to humans and likelihood of being shot by livestock managers. Second, the actual risk to livestock resulting from wild dog predation was evaluated from records of actual losses, as related to the method of livestock management and the presence of alternative (natural) prey. Availability of natural prey obviously reduces predation on livestock (Rasmussen 1999; Fritts et al. 2003). Third, and arguably most important, was the assessment of attitudes of the wider public for comparison against those of the local ranchers. Public pressure relating to the acceptability or not of killing predators can influence ranchers' attitudes.

This risk assessment phase led to the first action of circulating findings locally and nationally through newsletters, press and other media, to ensure transparency and rationality in the wild dog conservation campaign. This was effective in changing public attitudes and even generated support from ranchers, as confirmed by a reduction in the number of wild dogs being shot.

The next phase in the conflict management strategy was to determine if wild dogs were resident on a ranch, as evidenced by the location of breeding dens. If a pack was not resident, then no effective action could be taken apart

from maintaining contact and relations with the land owners. If a pack was resident, then the dogs were particularly vulnerable to retaliatory killing by ranchers because the den location would become common knowledge among ranchers suffering actual or perceived livestock depredation.

Three options arise for dealing with a resident wild dog pack on ranchland: (i) do nothing, perhaps allowing the dogs to raise their pups and disperse but probably resulting in the pack being persecuted; (ii) humane culling, although this has ethical and legal implications and can undermine public support for efforts to conserve an endangered species; (iii) translocation, if there are funds for the operation and a suitable release site. In the Nyamandlovu case, translocation was the selected option and indeed there were two highly effective wild dog translocation operations in Zimbabwe, with successful breeding at the release sites followed by pack fission and long-distance dispersal (Hartwig & Rasmussen, 1999), which is essential for gene flow.

The project eased relations among ranch owners, local people and the conservation practitioners involved, generating real appreciation of attempts to find effective solutions to both livestock depredation and endangered species conservation. As a result, when new wild dogs arrived as expected to fill the vacuum caused by the translocation, ranchers tolerated the newcomers for 3 years until management options had to be revisited. There is no perfect solution when an endangered species kill livestock, and dedicated conservation practitioners are continually required at the human–wildlife interface. Nevertheless, the Zimbabwe wild dog project has provided a model for managing conflicts involving endangered carnivores in a mixed wildlife–livestock landscape.

Protecting a ‘pest’: dingos in Australia

The dingo (*Canis lupus dingo*) is the largest terrestrial predator in Australia and has managed to radiate into virtually all habitats across the country since its introduction from Asia around 4000–6000 years ago (Corbett 1995; Savolainen et al. 2004). It is a major predator of livestock (the primary cause of conflict with humans), causing millions of dollars of damage each year, as well as the costs associated with its control (Allen & Sparkes 2001). This includes the maintenance of one of the world’s longest man-made structures, the dingo barrier fence, which is over 5000 km in length and comprises poison baiting, trapping and shooting programmes. Dingoes also carry disease, predate on

pets (Dickman & Lunney 2001; Fleming et al. 2001) and, in some isolated circumstances, have attacked humans, with two instances of human death recorded.

The management of dingoes in Australia is a complex and expensive exercise and is complicated by the fact that the species is at the same time both a declared pest (legally requiring it to be controlled) and a protected native species in conservation lands (Fleming et al. 2006). Public opinion about the species is similarly divided. The situation is further complicated by the recent listing of dingoes on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List as *Vulnerable*, with the main threatening processes being hybridization with domestic dogs and lethal control methods employed by humans (Johnson et al. 2007).

Dingoes are normally generalist in their approach to survival and are able to exploit most habitats and food sources. This greatly enhances the potential for conflict with humans as the number of ways in which they can interact also increases. Many 'traditional' dingo habitats have been inhabited by humans, providing competition for space and other resources. There is also a tendency for human settlement to increase the availability of some resources (such as food) for dingoes.

While human–dingo conflict is increasing dramatically in urban and semi-urban areas in Australia, large landowners in the rangelands are often the most affected (or at least, perceived to be) by these conflicts in terms of the personal, financial and psychological costs borne. Financial costs include lost livestock (mainly sheep), opportunity costs of reduced yield and control costs. Psychological costs often arise from the trauma of witnessing predation impacts upon stock and pets, as well as stress arising from financial strain. The dingo has been persecuted as a result, and in many cases, this persecution has led to an increase in the impacts that the control measures have tried to address. Increased poison baiting campaigns have, in many cases, led to an increase in predation rates on livestock. It is believed that dispersing individuals, not part of stable packs, tend to attack livestock more frequently, and the removal of local stable packs allows these dispersers to invade areas they would not normally be able to (Allen 2000; Allen & Sparkes 2001). A potential secondary effect of local dingo removal is an increase in the numbers of mesopredator and competing native herbivore (e.g. macropods) species, further impacting the livestock industry through loss of stock and reduced yield.

For the Australian livestock industry to remain viable, there needs to be a change in the way dingoes are viewed and the focus of control programmes.

To some extent, this is already happening with many abandoning the traditional sheep industry in favour of cattle, which are less likely to be impacted by dingoes. Many are also reducing baiting campaigns and using alternative non-lethal methods such as guard animals to reduce the impacts of dingoes on their stock. As the benefits of these alternative approaches become more apparent, their uptake is expected to increase. The question that remains to be answered is whether it is, as some have suggested (e.g. Daniels & Corbett 2003), too late to ensure the continued survival of the dingo as we know it today.

Culture and conflict: jaguars in South America

Similar to the dingo in Australia, the jaguar (*Panthera onca*) is the largest terrestrial predator of Central and South America. Renowned for its power, the jaguar has always been feared and hunted, yet also admired for its exceptional strength, elegance and beauty, which explains the strong cultural significance of the species. However, an additional dimension evolved in the relationship between humans and jaguars when domestic livestock was introduced to South America (Arnold 1968) and jaguar predation on cattle resulted in hostility of ranchers toward jaguars.

Attacks by jaguars on humans are extremely rare, but jaguar predation on cattle has long been documented in the Brazilian Pantanal (Roosevelt 1914) and since the late 1970s, scientific studies conducted in that region, and later in the Venezuelan Llanos and other sites, have contributed to our understanding of jaguar feeding ecology and the relationship of jaguars to livestock in the rangelands of South America (Mondolfi & Hoogesteijn 1986; Hoogesteijn & Mondolfi 1992; Crawshaw & Quigley 2002; Dalponte 2002). More than 85 species have been recorded in the jaguar's diet (Seymour 1989) from frogs to tapirs, but in some areas where cattle are ranched on prime jaguar habitat, such as the Pantanal and the Llanos, cattle can become the most frequent prey species for jaguars (Hoogesteijn & Mondolfi 1992; Crawshaw & Quigley 2002; Dalponte 2002).

Some factors increase the likelihood of cattle depredation, including scarcity of wild prey (Aranda 2002; Nunez et al. 2002; Polisar et al. 2003), persecution of jaguars, which can result in wounded individuals whose injuries make it difficult for them to capture wild prey (Rabinowitz 1986), and poor livestock husbandry practices (Schaller & Crawshaw 1980; Schaller 1983). In the Pantanal and Llanos cattle are typically left unattended, often near or

even inside forested areas, which makes them more vulnerable to predation (Crawshaw & Quigley 2002; Hoogesteijn 2003). This leads to livestock losses that are unrelated to jaguars, but often blamed on them. Indeed, studies have shown that in the large ranches of the Pantanal and the Llanos predation by jaguars is a minor cause of cattle mortality compared to other causes, such as disease, abortion, malnutrition, attacks by vultures on newborn calves and puma depredation (Schaller 1983; Hoogesteijn et al. 1993). The relative economic damage associated with jaguar predation also varies. However, livestock losses to felids are generally low and less than 1–3% of total stock per year (Jackson et al. 1994; Farrell 1999), reaching 6% in the worst cases (Hoogesteijn et al. 1993).

These findings have led to a number of recommendations for resolving the conflict by attempting to decrease and compensate for economic damage. Electric fences (Saenz & Carillo 2002; Schiaffino et al. 2002; Scognamillo et al. 2002), translocation of ‘problem jaguars’ (Rabinowitz 1986; Linnell et al. 1997; Vaughan & Temple 2002), the introduction of water buffaloes (Hoogesteijn 2003) and improved cattle husbandry and management practices (Weber & Rabinowitz 1996; Crawshaw & Quigley 2002; Hoogesteijn et al. 2002) are examples of interventions. Compensation payments for the cattle killed by jaguars (Nowell & Jackson 1996; Hoogesteijn et al. 2002; Perovic 2002; Vaughan & Temple 2002; Conforti & de Azevedo 2003), the implementation of wildlife-based tourism (Weber & Rabinowitz 1996; Dalponte 2002; Miller 2002; Conforti & de Azevedo 2003) and trophy hunting of problem jaguars (Swank & Teer 1992) have also been tried or proposed. However, so far the evidence that any of these interventions can effectively reduce hostility towards jaguars is scarce and conservation efforts focused solely on the ecological and economic dimensions of human–jaguar conflicts have still not resulted in noticeable change throughout much of the jaguar’s range.

Indeed, the above interventions will have little effect if jaguar persecution is found to be socially and culturally ingrained. Recent research on ranches and farms in Brazil suggest that rural attitudes to jaguars are not dictated by material loss caused by the animal (Conforti & de Azevedo 2003; Zimmermann et al. 2005) and negative attitudes to the species are also found among farmers who do not raise cattle (Marchini 2006). Therefore, factors other than the economics also determine negative attitudes, and the resulting hostility, to jaguars. Fear, prejudice, the social significance or simply the excitement of hunting a large predator, among other socio-cultural phenomena, also explain why people persecute jaguars. It is imperative then that we broaden the scope

of our current approaches to resolve human–jaguar conflicts. Future research should turn to the human side of the conflict in order to (i) understand people’s behaviour towards jaguars and identify the factors that determine hostility towards the species, (ii) develop education and communication interventions to engage landowners in the effort to resolve the conflict, improve their perceptions of the issue and increase their tolerance to jaguars, taking advantage of the exceptional socio-cultural significance of the species and (iii) compare approaches for human–jaguar conflict mitigation in a broader spectrum of ecological, economic, political, social and cultural circumstances, from large cattle ranches in the Pantanal and Llanos to small farms in other parts of the continent. Our coexistence with jaguars in the rangelands of South America depends upon the recognition that the origin – and therefore the resolution – of the conflicts between humans and jaguars lies on the human side of the conflict.

When people become prey: tigers in Asia

The tiger (*Panthera tigris*) has suffered a severe decline in its population distribution over the last decade (Biswas & Sankar 2002). It is estimated that between 3400 and 5140 individuals remain in the wild (Chundawat et al. 2008), inhabiting only 7% of the species’ original range (Sanderson et al. 2006). Although now predominantly associated with tropical and temperate broadleaf forests, tigers also inhabit grassland and shrubland habitats, such as the Terai–Duar landscape, which includes the Chitwan and Royal Bardia National Parks (Nepal) and Jim Corbett National Park (India).

Much like the jaguar, the tiger is both feared and admired across its range and conflict with people has undoubtedly contributed to its population decline. Unlike its Latin American counterpart, however, tigers also occasionally attack people, a dimension that significantly complicates this case of human–carnivore conflict. In areas where attacks on people occur, fear inevitably exacerbates communities’ animosity towards tigers. The resultant retaliatory killing of tigers is widespread in Asia and occurs even within protected areas. As most of Asia’s protected areas are relatively small (Wikramanayake et al. 1999), tigers often range into adjacent, human-dominated habitats, where conflicts also arise. Human–tiger conflict is therefore often most severe in moderately disturbed habitat areas, such as buffer zones around protected areas (Nyhus & Tilson 2004a,b).

The scale of human–tiger conflict in rangelands, in particular, the number of attacks on humans per location, varies. Attacks on humans have been reported in both the area surrounding Chitwan and Royal Bardia National Parks where, in 1998–9, 11 deaths were reported, marking a sudden departure from the Park’s prior average of 1.3 attacks per year (McDougal 1999). Attack rates also vary throughout the rest of the tigers’ range. In areas of low human and tiger density, attacks on people are rare (Nowell & Jackson 1996). In the Russian Far East, for example, Miquelle et al. (1999) reported only six unprovoked attacks on humans since 1970. Conversely, in India’s Dudhwa National Park, over 200 people were killed between 1978 and 1996 (Nowell & Jackson 1996), and in Sumatra over 170 people were killed or injured in tiger attacks over a 20-year period (Nyhus & Tilson 2004a). The Sundarbans of India and Bangladesh are most notorious for ‘man-eating’ tigers, with an official figure of an average of 24 (and an unofficial estimate of approximately 100) people killed per year (Reza et al. 2002). Attacks are generally attributed to people entering reserves to harvest natural resources (Nowell & Jackson 1996; Reza et al. 2000; Mukherjee 2003), cultivation of land around reserves (Nowell & Jackson 1996) or to hunters wounding tigers (Miquelle et al. 1999).

More often than attacking people, tigers kill livestock and a number of studies have quantified these predation losses. For example, livestock constitutes 0.45–12% of tigers’ diets in four Indian protected areas (Biswas & Sankar 2002; Bagchi et al. 2003; Reddy et al. 2004; Andheria et al. 2007). In the Russian Far East, it has been estimated that up to 100 heads of livestock are killed each year by tigers (Miquelle et al. 2005), while in Sumatra at least 870 head of livestock were reportedly killed over a 20-year period (Nyhus & Tilson 2004a) and across Indochina livestock losses to tigers are common (Johnson et al. 2006). Livestock depredation tends to be particularly severe in those areas where tigers’ wild prey base has been significantly reduced (Johnson et al. 2006; TIGRIS Foundation 2007).

Various methods have been implemented or suggested to reduce human–tiger conflicts, including compensation schemes (Madhusudan 2003; TIGRIS Foundation 2007), changes to cattle husbandry practices (Johnson et al. 2006), village eco-development (Bagchi et al. 2003) and the use of face masks worn on the back of the head (Nowell & Jackson 1996). As with jaguars, few quantitative data are available on the effectiveness of such mitigation techniques, although observations have been recorded. While in the Sundarbans no attacks on people wearing face masks have been reported

(Mukherjee 2003), compensation schemes have generally been found to be inefficient and ineffective (Madhusudan 2003).

More detailed and up-to-date data describing the frequency, distribution and determinants of attacks on humans by tigers in rangelands and in other habitat types are urgently required if we are to understand the dynamics of human–tiger conflicts, range wise. The extent of livestock depredation must also be examined extensively. Monitoring and evaluation of existing mitigation strategies is required to complement this research, as it is fundamental to the development of effective mitigation techniques. The applicability and feasibility of new mitigation and land management techniques must also be explored for reducing human–tiger conflict. For example, the potential of community-based work and alternative livelihood schemes to reduce the number of people entering reserves should be investigated, as should the effectiveness of economic incentive and insurance schemes in comparison to existing compensation schemes. Buffer zones, in particular, are associated with a high probability of conflict, yet, if managed specifically with this in mind, they can be used to reduce human–tiger conflict in a wider area, and the effectiveness of multiple land use practices in reducing conflict must therefore also be investigated (Nyhus & Tilson 2004b). Habitat corridors and meta-population management of tiger habitats is becoming increasingly important as habitat becomes progressively fragmented (Wikramanayake et al. 2004), and the maintenance of suitable habitat and wild prey base must remain a priority for the conservation of tigers in human-dominated landscapes (Reza et al. 2000). Finally, understanding the human dimension of human–tiger conflict is essential.

Re-emerging conflict: lynx in Europe

The previous case studies highlight that although conflicts between large carnivores and people and their livestock are a global phenomenon, the extent of the conflict varies greatly. In this final case study, we discuss what is possibly the greatest depredation conflict that occurs in the rangelands of Norway. Norway is a rugged country with the lowest human population density in Europe and where less than 5% of the land area is suitable for cultivation. The rest of the area consists of boreal forest (almost entirely used for intensive commercial forestry) and alpine tundra above the tree line.

With so little farm land it has been the tradition for centuries to graze livestock in the forests and alpine tundra habitats. In the past, grazing animals

were accompanied by shepherds to protect them from predators. However, by the early twentieth century, large carnivore populations had been so reduced (wolves were actually exterminated) that it became possible to adopt a form of free-grazing where livestock (mainly sheep) were released in early summer and gathered in autumn. The animals were released into unfenced forest and alpine tundra habitat and only received occasional supervision. In the absence of large carnivores, losses for the approximate 4-month grazing season were remarkably low, in the region of 1–2% for ewes and 5% for lambs.

However, since the 1980s the populations of all four large carnivore species in Norway [brown bear (*Ursos arctos*), wolf, Eurasian lynx (*Lynx lynx*) and wolverine (*Gulo gulo*)] have begun to recover due to conservation-orientated legislation. This recovery has been associated with a dramatic increase in depredation losses of livestock to the large carnivores. Eurasian lynx are the most widespread of the four large carnivore species and are, together with wolverine, responsible for the greatest losses of livestock. Lynx have been the subject of intensive radio-telemetry based studies during the last decade (Scandlynx 2007). Between 1996 and 2005 lynx numbers have fluctuated between 300 and 500 individuals (the fluctuations are caused by hunter harvest) and compensation has been paid for between 6000 and 9000 sheep, mainly lambs killed each year. Not all losses are documented, but a combination of documented losses combined with a range of studies where sheep have been radio-collared to identify the cause of loss has confirmed that these numbers are realistic. This totals approximately 20 sheep per lynx per year. The results of an ongoing study in which lynx have been radio-collared and intensively monitored have confirmed as realistic the calculated kill rates. The project has also shown that virtually all lynx will kill sheep at some stage, but that adult males and juvenile lynx kill far more sheep than adult female lynx and that while the diet of lynx is dominated by wild ungulates, sheep do constitute a significant proportion of a summer diet (26%), which, given that unguarded livestock far outnumbered wild ungulates in our study area, was a surprisingly low proportion. In contrast to depredation by tiger and hunting dog, the data also indicated that the probability of a lynx killing sheep increased with the density of wild prey in the area. These results combined to build a picture of a conflict situation, where lynx are only incidentally killing livestock that they encounter while pursuing their wild prey. However, because unguarded sheep are found at high density throughout the natural habitats exploited by lynx and their preferred prey, lynx–sheep encounters occur frequently, resulting in depredation. The data further indicated that this

is not due to specific problem individuals, but rather that all lynx at some stage kill livestock.

It is therefore not surprising that the only way lethal control reduces depredation is in circumstances where it reduces the lynx population. The modern Norwegian ‘tradition’, of placing free-ranging and unguarded sheep directly into forest habitats where large carnivores occur is a recipe for maximum conflict. Unfortunately, high labour costs in Norway make the restoration of the original shepherding tradition virtually impossible and even fencing sheep requires an expensive and radical restructuring of an industry that is already highly subsidized. The only alternatives for lynx are to accept losses or phase out sheep. However, in areas where other large carnivores such as bears, wolves and wolverines also occur, the combined depredation pressure on livestock holdings will probably force change. Comparative studies from France, Switzerland and Eastern Europe have shown that confining sheep to fenced fields or alpine pastures (out of the forest) dramatically reduces depredation losses per lynx and that depredation becomes more associated with specific individuals. Adopting mitigation measures such as electric fences, night-time enclosures or livestock-guarding dogs can basically reduce the problem to zero (Odden et al. 2002; Linnell & Brøseth 2003; Herfindal et al. 2005; Moa et al. 2006; Odden et al. 2006).

Conclusion

Our set of case studies illustrates that although human–carnivore conflicts occur in a great range of geographic and socio-economic contexts, on a global scale the challenges and experiences are remarkably similar. Compromises to the ecological needs of carnivores predispose them to livestock killing and the severity of each conflict is inextricably linked to the attitudes and beliefs of the communities affected. Perceptions of conflict are often formed by a few memorable or catastrophic events and reflect not only those events experienced first-hand, but historical events and often the stories from other people and communities (Naughton-Treves & Treves 2005; Treves 2007). As such, perceptions of conflict severity may not accurately reflect real conflict severity.

Similarly, the results of scientific research may not provide an entirely accurate picture. Conflict incidents tend to be randomly distributed within and between communities and the few individuals, households or communities

that suffer the most devastating losses may be masked by the regional or community averages commonly used in scientific literature to describe losses. Scientific research is also rarely able to capture more extensive geographic and historic perspectives of a conflict situation due to restricted study areas and short time frames (Treves 2007). Consequently, when devising mitigation strategies, both the ‘perceived’ and the ‘scientific’ views of conflict must be considered, as when viewed together they provide a more comprehensive insight into conflict severity.

Globally, conflict mitigation techniques are plentiful, but efforts to systematically evaluate these are lacking and mechanisms for easy exchange of lessons learnt are only beginning to be established. To manage conflicts with greater success worldwide, we need to understand better the spatial and ecological dynamics of human–wild interfaces, focus on the importance of the human dimension of these conflicts, compare mitigation results and tailor mitigation approaches to the characteristics of individual cases. Although there are species-by-species differences among these conflicts, the core issues as well as the principles outlined in this chapter apply widely and are crucial to the successful management of human–wildlife conflicts on wild rangelands.

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Appendix 5:

Cattle ranchers' attitudes to conflicts with jaguars in the Pantanal of Brazil.

Zimmermann, A., Walpole, M. J., & Leader-Williams, N. (2005) Cattle ranchers' attitudes to conflicts with jaguars in the Pantanal of Brazil. *Oryx*. 39 (4): 406-412.

Cattle ranchers' attitudes to conflicts with jaguar *Panthera onca* in the Pantanal of Brazil

A. Zimmermann, M.J. Walpole and N. Leader-Williams

Abstract Across its range in Latin America the jaguar *Panthera onca* is threatened by habitat loss and through conflict with people. In the Pantanal of Brazil, where large areas of land are devoted to cattle ranching, jaguars often attack livestock and are persecuted by ranchers. However, the extent to which livestock predation and/or other socio-economic factors affect ranchers' tolerance of jaguars is unclear. This study examined ranchers' attitudes towards jaguars and conservation in the northern Pantanal in order to identify ways of resolving jaguar-rancher conflict. The results suggest that most respondents supported the conservation of the Pantanal but that attitudes towards jaguars were mixed and difficult to predict on the basis of socio-economic factors. Attitudes

towards jaguars were more closely related to respondents' age and relative wealth than to jaguar-related benefits through tourism or costs through cattle predation. Whilst efforts to reduce cattle losses are needed, it may be equally as important for conservation initiatives to focus on the inherent appreciation of the natural value of the Pantanal within this ranching community.

Keywords Attitudes, conservation strategies, human-wildlife conflict, jaguars, livestock predation, Pantanal, *Panthera onca*.

This paper contains supplementary material that can only be found online at <http://journals.cambridge.org>

Introduction

Wildlife-human conflict is a widespread conservation issue of increasing concern to conservationists (Woodroffe *et al.*, 2005). Livestock is often killed by predators living close to farmland and pastures (Nyhus & Tilson, 2004; Patterson *et al.*, 2004). Livelihoods can be severely affected by such depredation, generating negative attitudes and persecution of the culprits (Woodroffe & Ginsberg, 1998; Hussain, 2003).

The extent to which people tolerate wildlife damage may be influenced by various socio-economic factors, including relative wealth, levels of education, the extent to which people derive monetary or other benefit from wildlife, and the magnitude of wildlife-associated costs (Oli *et al.*, 1994; de Boer & Baquete, 1998). However, personal values also have an important influence on attitudes towards conservation (Naughton-Treves *et al.*,

2003). Therefore, understanding which factors influence attitudes and tolerance in different situations is key to choosing and targeting the most appropriate solutions, whether mitigation to reduce losses (Ogada *et al.*, 2003), education to improve awareness (Marker *et al.*, 2003), or benefit generation to provide incentives (Mishra *et al.*, 2003).

In Central and South America conflict between jaguars *Panthera onca* and cattle ranchers is common and leads to serious livelihood losses and the killing of many jaguars. The jaguar, categorized as Near Threatened (IUCN, 2004), is the third largest cat species and exists in a wide variety of habitats, within and outside protected areas (Nowell & Jackson, 1996). The jaguar's natural prey base is extremely diverse, with over 85 species recorded in its diet across different parts of its range (Mondolfi & Hoogesteijn, 1986; Nowell & Jackson, 1996). Domesticated animals including cattle, horses, donkeys, dogs and pigs also constitute important prey items. Many cattle ranches in South America occupy formerly prime jaguar habitat, and therefore livestock has become easy prey for jaguars in Brazil and Venezuela (Crawshaw & Quigley, 1991; Hoogesteijn *et al.*, 1993).

Although livestock losses to jaguars have been quantified in a number of sites, there have been few studies of its impact on local attitudes. A recent study by Conforti & Azevedo (2003) measured attitudes towards jaguars around the 1,700 km² Iguazu National Park in Brazil. Unlike the Iguazu region, the 200,000 km² Pantanal in Brazil is a major stronghold for jaguars globally. The

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Received 10 January 2005. Revision requested 21 April 2005. Accepted 7 June 2005.

Pantanal, however, lacks an extensive network of protected areas, and jaguars must coexist with ranchers on private lands if they are to survive in this economically important region. Therefore, an understanding of the attitudes of the ranchers, who make most decisions about land use in the Pantanal, is vital for the conservation of the global jaguar population. Our study not only explores the attitudes and conservation values of ranchers, but also seeks to disentangle the effects of economic costs and benefits, social factors, and intrinsic values upon such attitudes, placing the results in the context of future jaguar conservation strategies.

Study area

The Pantanal is the world's largest wetland and spans some 200,000 km² across the borders of Brazil, Bolivia and Paraguay (Coutinho *et al.*, 1994; Por, 1992; Fig. 1). The region was settled by cattle ranchers over 200 years ago (Wilcox, 1999). The first ranches were many hundreds of thousands of hectares in area, but were later subdivided amongst sons and so the largest of today's ranches are c. 100,000 ha. Nevertheless, c. 98% of the Pantanal remains privately owned (Gottgens *et al.*, 1998).

The study took place in the northern Pantanal, covering the administrative districts of Cáceres, Poconé and

Barão de Melgaço in the Brazilian state of Mato Grosso. The study area was defined by the federal boundaries of each district, except to the north where the Pantanal biome recedes before the northern limits of Cáceres and Poconé districts. The total area of the three districts within the Pantanal biome is approximately 35,700 km², comprising c. 26% of the Brazilian Pantanal. There are two protected areas in the northern Pantanal, Estação Ecológica Taiamã (120 km²) and Parque Nacional do Pantanal (1,400 km²) with its three associated private reserves (530 km²), leaving 33,650 km² available for ranching. The only road leading into the Pantanal is the 150 km-long *Transpantaneira*, alongside which are many ranches.

The last status surveys of jaguars in the Pantanal date from the 1980s (Crawshaw & Quigley, 1991; Quigley & Crawshaw, 1992). However, ranchers state that jaguars are present in all three districts of the northern Pantanal, although their distribution is patchy. Generally, the highest densities of jaguars occur on both sides of the Paraguay River, in the southern parts of Cáceres and Poconé districts.

Methods

A structured questionnaire in Portuguese was administered by interview during May-June 2000 to ranchers

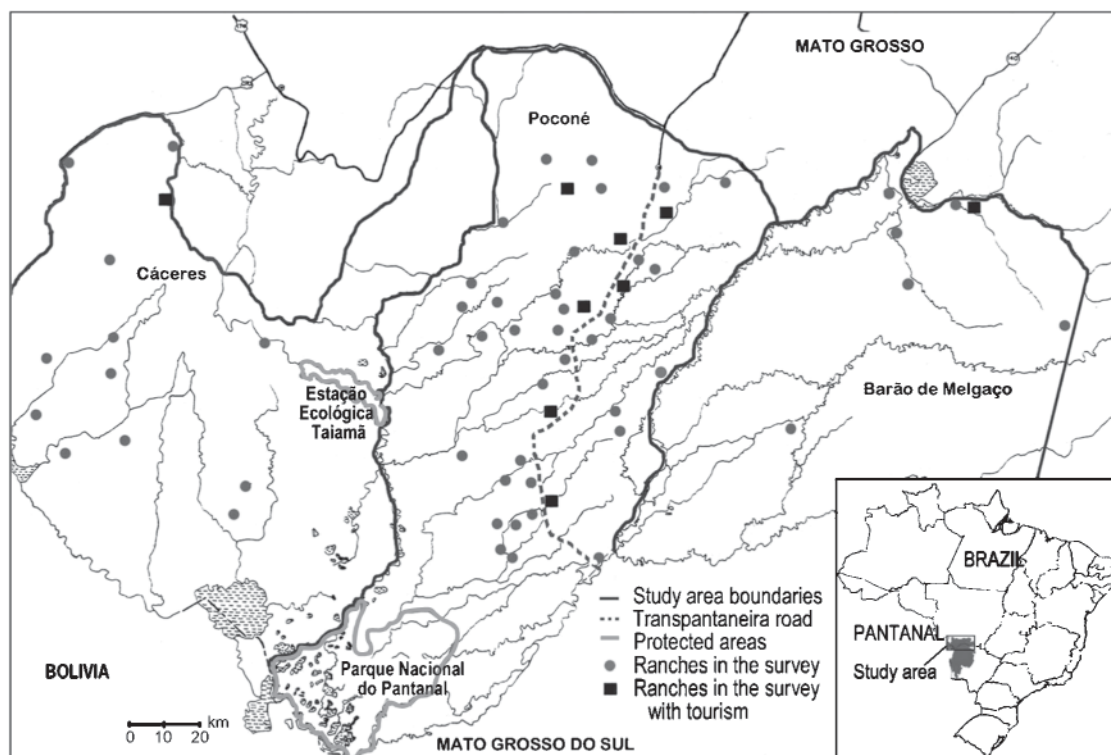


Fig. 1 Map of the study area showing locations of ranches whose owners were interviewed. The inset indicates the location of the study area in Brazil.

from each district. Some properties near the *Transpantaneira* could be visited on site but many others were inaccessible overland. Hence, many ranchers were interviewed in their second residences in the nearest towns or at cattle auctions and lasso club events. By interviewing most ranchers away from their ranch, bias towards selecting accessible over inaccessible ranches was reduced. As a result, the ranches of respondents were widely distributed across the study area (Fig. 1).

Following a series of socio-economic questions concerning the age of respondents, the size of ranch, number of cattle, and number of dependents, respondents were asked about their experiences of jaguars, including the number of cattle predated on their ranch in the preceding full calendar year. They were also asked about their involvement in, and the benefits derived from, tourism. Attitudes were explored using a series of suggested statements regarding jaguars and conservation, and responses were recorded on a five-point Likert scale (Appendix).

Analysis was conducted using *SPSS v.10* (SPSS Inc., Chicago, USA). Descriptive statistics were derived for all factual and attitudinal questions. Bivariate analyses were conducted between individual attitude statements and potential explanatory variables. Relationships with categorical variables, such as age class and dependence upon tourism, were analysed using the χ^2 test. Relationships with continuous variables such as ranch area, number of cattle, cattle density, number of cattle lost to jaguars, and proportion of cattle lost to jaguars, were

examined using two-sample *t*-tests. For these and subsequent analyses the explanatory variables were \log_{10} transformed to better approximate a normal distribution.

The answers to six of the jaguar attitude statements were combined into a single additive score (cf. Mehta & Kellert, 1998; Walpole & Goodwin, 2001). Answers to each question were coded from zero to four (strongly negative, negative, unsure, positive, strongly positive), and the codes summed to create a combined score from zero to 24, with higher scores indicating a more positive overall attitude to jaguars. The internal consistency of this combined score was high (Cronbach's alpha = 0.70), suggesting that it was truly additive and reflective of overall attitude. Relationships between the combined score and potential explanatory variables (respondent's age, ranch size, cattle herd size and density, reported cattle losses, and involvement in tourism) were analysed using *t*-tests, analysis of variance and Pearson's correlation coefficient. Multiple stepwise linear regression was used to identify which combination of explanatory variables best predicted the overall attitude score.

Results

Characteristics of sample

Fifty respondents completed the questionnaire, most of whom were 41–50 years old and most (66%) had lived at their ranch for 20 years or more. Ranch sizes varied greatly, but the majority (56%) were <5,000 ha in size

Table 1. Summary of all attitude statement results.

Attitude statement	Agreement rate (%)*
Jaguars are a threat to cattle	82
Jaguars are a threat to humans	34
At this ranch we cannot tolerate jaguars taking any cattle	64
I would be happier if there were no jaguars at all	40
Jaguars deserve protection	74
A solution to the problem of jaguar preying on cattle needs to be found	90
Jaguar predation on cattle is a problem that the local authorities should address	80
The jaguar problem is for each ranch to solve on its own	44
I/we would like to receive help at this ranch in solving the jaguar depredation issue	94
I benefit directly from tourism	20
Tourism in the Pantanal is disruptive to my lifestyle and traditions	20
I am worried about the effects of the construction of the Hidrovia	42
I am in favour of paving the Transpantaneira	36
The Pantanal needs more development	82
The nature/ wildlife of the Pantanal is a national treasure	100
The nature/ wildlife of the Pantanal is adequately protected	12
I am worried about the future of the Pantanal's nature/ wildlife	94
I consider myself aware of conservation problems in the Pantanal	96
The Pantanal needs more national parks or nature reserves	46
The existing laws are useful in protecting Pantanal wildlife	22
I am concerned about overfishing in the Pantanal	92
I would like to communicate more with conservation scientists and organisations	86

*% of respondents who strongly agreed with the statement

(median = 4,000 ha, mean = 12,950 \pm SE 3,174 ha). The total area of land owned by all respondents combined was 647,504 ha, which covers 19% of the area available for ranching within the northern Pantanal. The majority (56%) of respondents owned 1,000 or less head of cattle (median = 1,000, mean = 1,980 \pm SE 418). There was a positive relationship between log (ranch size) and log (number of cattle) ($r = 0.622$, $P < 0.001$) but a negative relationship between log (ranch size) and log (cattle density) ($r = 0.512$, $P < 0.001$). Most (82%) respondents were not presently active in tourism. Those involved in tourism ($n = 9$) had fewer cattle than other ranchers ($t_{48} = 3.14$, $P < 0.01$).

Livestock predation by jaguars

Most (82%) respondents have suffered cattle losses to jaguars and most (66%) believed that jaguar attacks were becoming more common. Most respondents (62%) reported that jaguar attacks did not show any clear seasonal pattern. Of ranchers claiming to have lost cattle to jaguars in 1999, the average number lost that year was 23 \pm SE 4.3, representing 2.3% of cattle holdings. There was a positive relationship between cattle lost and both log (ranch size) and log (number of cattle) ($r = 0.413$, $P < 0.01$, and $r = 0.541$, $P < 0.001$, respectively). However, the proportion of cattle lost declined with increasing ranch size and with cattle numbers $r = -0.590$ and -0.716 , both $P < 0.001$).

Attitudes towards jaguars and conservation

Most respondents (82%) perceived jaguars as a threat to cattle, whereas fewer (34%) perceived them as a threat to

humans. Most (94%) felt that it was important to solve the problem of cattle predation and wished to receive help with this, while most (80%) felt that local authorities should be addressing the issue. More than half (64%) of respondents could not tolerate jaguars on their ranch, but only 40% would be happier if there were no jaguars at all. Paradoxically, 74% felt that jaguars deserve protection. When asked about the extent of losses of cattle to jaguars, 60% expressed much concern over the issue. From a list of problems that commonly affect ranching, 38% perceived the jaguar to be of most concern (Fig. 2).

The sensitive issue of whether ranchers still shoot jaguars was explored by asking respondents whether other ranchers in the northern Pantanal killed jaguars to prevent cattle losses. Most respondents (88%) replied yes, 10% responded with a more cautious maybe or don't know and 2% said no.

Ranchers mostly agreed about a number of wider conservation issues. All respondents felt that the Pantanal is a national treasure, and most (94%) were worried about its future. Most (88%) felt that the Pantanal is not adequately protected and 78% believed that existing laws were not sufficient to protect its wildlife. However, respondents were divided in their opinions about whether the Pantanal needs more protected areas (46% in favour).

Factors influencing attitudes to jaguars

There were few clear relationships between attitudes towards jaguars and underlying socio-economic factors. Unsurprisingly, those who thought jaguars were a threat to cattle had reported significantly more cattle losses ($t_{43} = -3.12$, $P < 0.01$), as had those that worried about

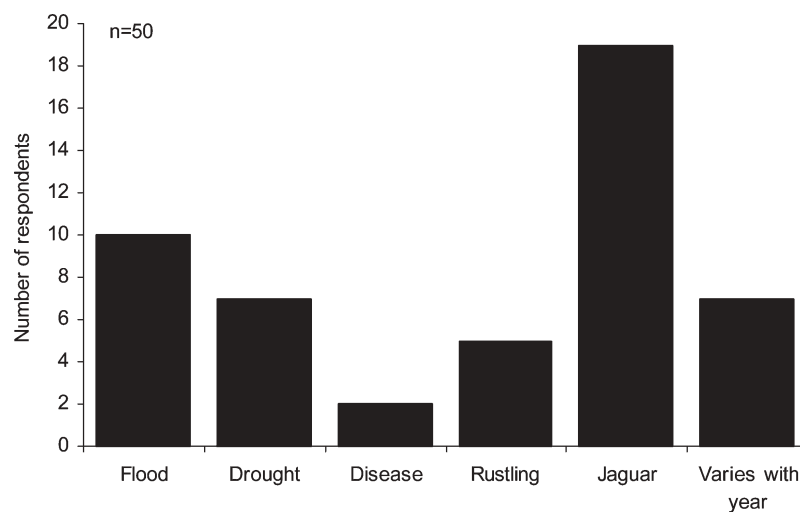


Fig. 2 Respondents' perceptions of the main problems affecting their income from cattle.

losses ($F_{2,42} = -16.7, P < 0.001$). Equally, those who indicated that they could not tolerate jaguars taking cattle on their ranches had lost a marginally higher proportion of their cattle than more tolerant respondents ($t_{32} = -1.97, P = 0.058$).

Values for the combined jaguar attitude score ranged from 2 (very negative) to 24 (very positive), with a mean score of $13.4 \pm \text{SE } 0.68$. There was no significant relationship between the combined attitude score and area of ranch, number of cattle, number or proportion of reported cattle losses, or involvement in tourism. However, there was a weakly significant negative relationship with cattle density ($r = -0.332, P < 0.05$; Fig. 3a). Equally, there was a weak relationship with the age of respondents ($F_{5,44} = 2.72, P < 0.05$), in that respondents >60 years old held more negative views of jaguars than younger respondents (Fig. 3b). Multiple regression did not reveal any combination of variables

that could better explain the overall pattern of jaguar attitude scores.

Discussion

Attitudes towards jaguars and conservation

The results suggest that the ranchers of the northern Pantanal suffer livestock losses that they are mostly not willing to tolerate, and yet they also appreciate the intrinsic natural value of the Pantanal and regard its conservation as important. Ranchers often considered the jaguar to be the most beautiful animal in their environment (survey respondents, *pers comm.*) but, as reflected by their attitudes, this perception is no guarantee that they will protect it. Their response to the statement 'jaguars deserve protection' was often 'yes, but not on my ranch'. Where ranchers were sympathetic to jaguar conservation, this appeared to originate from personal, pro-conservation attitudes.

Research undertaken across the tropics suggests that wildlife-associated costs reduce tolerance and support for conservation and vice versa (Newmark *et al.*, 1993; de Boer & Baquete, 1998). Other studies have shown the importance of education and other socio-economic factors (Fiallo & Jacobson, 1995). The magnitude of livestock predation documented in this study (*c.* 2–3%) is not dissimilar to that recorded for other large cats in a range of locations (Oli *et al.*, 1994; Davies & du Toit, 2004; Patterson *et al.*, 2004). Yet in the northern Pantanal the broad spectrum of attitudes among ranchers does not appear to be heavily affected by socio-economic factors, nor by benefits gained through tourism, nor the costs of cattle predation. In fact, a number of the respondents who held strongly positive attitudes towards conservation and the protection of jaguars suffered extensive cattle losses and did not enjoy supplementary income from conservation.

The ranchers of the Pantanal have high standards of living compared with, for example, subsistence farmers in Africa who also suffer livestock losses to large carnivores. Relatively higher incomes may help to decouple their overall attitudes towards their losses. As a result, attitudes become shaped principally by individual perceptions, beliefs and values, influenced by education, upbringing, tradition, and culture.

Solutions for conservation and conflict resolution

Although ranchers agreed that the Pantanal needed better protection, opinions over the need for more protected areas were divided. In 1990 the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) launched the Reserva Particular do Patrimônio

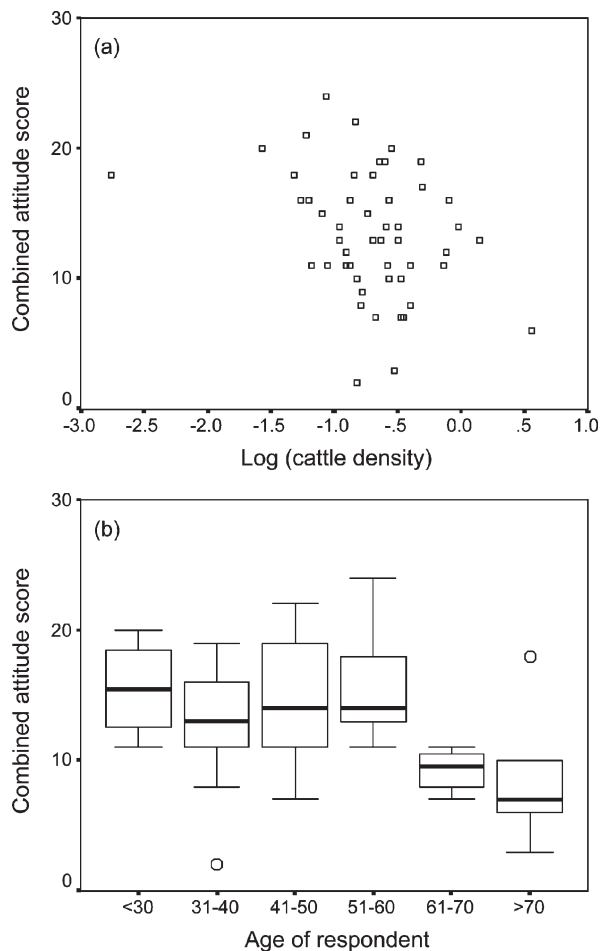


Fig. 3 Relationship between combined attitude scores (see text for details) of each rancher towards jaguars and (a) log cattle density on each ranch, and (b) age of respondent. Open circles in (b) represent outliers.

Natural scheme to expand Brazil's protected area network through land tax exemption options in return for designating land for conservation purposes (IBAMA, 2000). However, several ranchers commented that they subscribed to the scheme not because of tax savings, which they said were minimal, but because they cared about protecting the Pantanal.

Because law enforcement is logistically difficult in the Pantanal, conservation strategies on privately owned land may still need to rely on voluntary or self-enforcing mechanisms. Therefore, the Pantanal ranchers who are proud of their natural heritage and hold positive attitudes towards conservation are a powerful asset for future conservation planning. Our results suggest that incentive-based approaches (Hutton & Leader-Williams, 2003) such as tourism may not necessarily be the most important tool for improving or maintaining tolerance and support among Pantanal ranchers towards jaguars. Although benefits of tourism are generally welcomed, they have often been over-promoted as a panacea for conservation. In reality, benefits are limited, community-based tourism is rarely sustainable (Kiss, 2004) and most ranches are too inaccessible to attract profitable numbers of tourists. Instead, many ranchers expressed interest in trophy hunting as an option to reduce conflict.

Theoretically, a problem of wildlife conflict involving a large cat should lend itself to a strategy of sustainable extractive use, because it is possible for a professional hunter to track down the individual problem animal (Almeida, 1990). This would not only directly solve the rancher's problem and provide an incentive for tolerating losses, but would also address the welfare issue that jaguars are often shot and debilitatingly maimed by ranch workers. Yet if ranchers' views about the protection of jaguars are driven by their individual philosophies towards conserving charismatic species, then there may be no need to place financial value on these animals.

As long as ranchers and their workers perceive jaguars to be a problem, some will continue to persecute them. An alternative approach therefore may be to focus on reducing livestock predation to reduce the costs of conflict. The traditional husbandry practice in the Pantanal, where cattle are left to roam freely, exacerbates the problem. Simple changes to cattle husbandry practices in Venezuela have helped reduce the risk of jaguar depredation (R. Hoogesteijn, *pers comm.*), and similar techniques have been used to combat large carnivore depredation in Africa (Ogada *et al.*, 2003).

Alongside mitigation methods, our results suggest that any solution to the problem could also include education and raising awareness to maintain positive attitudes and increase tolerance. Such an approach has proved successful in raising the tolerance of cattle ranchers in Namibia towards cheetah, and reducing persecution (Marker *et al.*, 2003). In the case of the Pantanal,

it is important to build on the positive baseline of conservation values within the ranching community. For example, one community-based jaguar conflict management programme in the southern Pantanal (Zimmermann, 2003) has already used the insight gained in this study to create a rancher-oriented participatory approach to human-jaguar conflict mitigation.

Acknowledgements

This study was funded by the North of England Zoological Society and the Durrell Institute of Conservation and Ecology, with air travel provided by British Airways Assisting Conservation. Assistance and information were kindly provided by Fundação Ecotrópica and Associação Ecológica Melgassense, Polícia Florestal de Varzea Grande and Poconé, Sindicato Rural de Poconé, SEMATUR Cáceres, Angelika Jüncke, Gavur Kirst, Fernando diSerio, Adalberto Eberhardt, Wolf Eberhardt, Eduardo Meirelles, José Augusto Ferraz de Lima, Joaize Lopes, Fenelan Müller, Silvio Araujo, Estelito Rodrigues, Richard Mason, Christina Serrou, Peter Crawshaw, Cheryl Chetkiewicz and the many ranchers who responded to the questionnaire.

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Appendix

The appendix for this article is available online at <http://journals.cambridge.org>

Biographical sketches

Alexandra Zimmermann is interested in human-wildlife conflict, particularly how culture and social psychology influence relationships with wildlife. She has led a community-based jaguar conflict management programme in Brazil for the Wildlife Conservation Society, and currently coordinates field conservation programmes for Chester Zoo, including an elephant conflict mitigation project in India.

Matt Walpole was at the Durrell Institute of Conservation and Ecology (DICE) for 10 years, specializing in multidisciplinary approaches to conservation, including human-wildlife conflict mitigation and the role of ecotourism as a conservation and development tool. He recently moved to Fauna & Flora International where he coordinates a global project exploring the links between livelihoods and conservation.

Nigel Leader-Williams' interests include sustainable use, law enforcement and community-based conservation. He has studied introduced reindeer on South Georgia and black rhinos in Zambia, and has advised the government of Tanzania on wildlife policy. He is currently Professor of Biodiversity Management at DICE.