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CHAPTER 17

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

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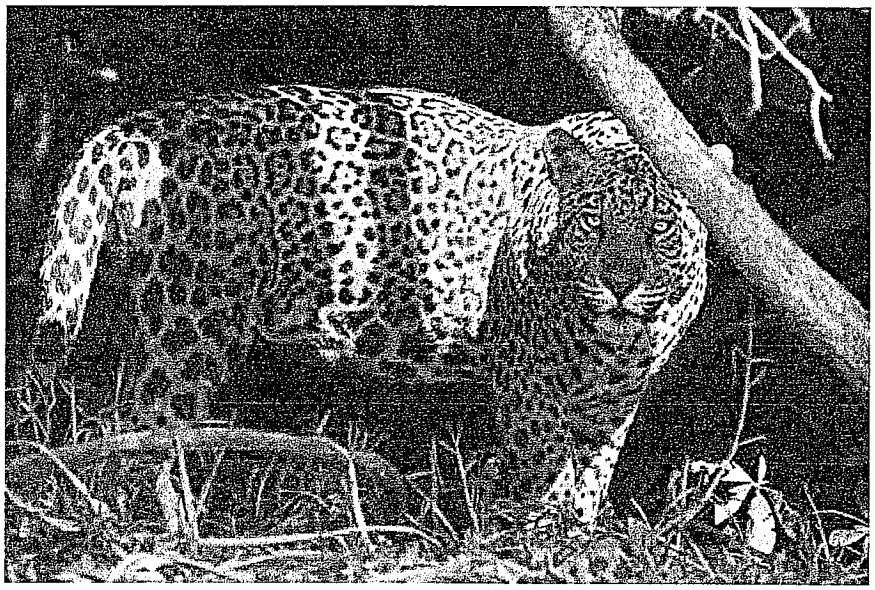

Jaguar on a riverbank, Paraguay river, Pantanal, Brazil. © Edson Grandisoli.

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

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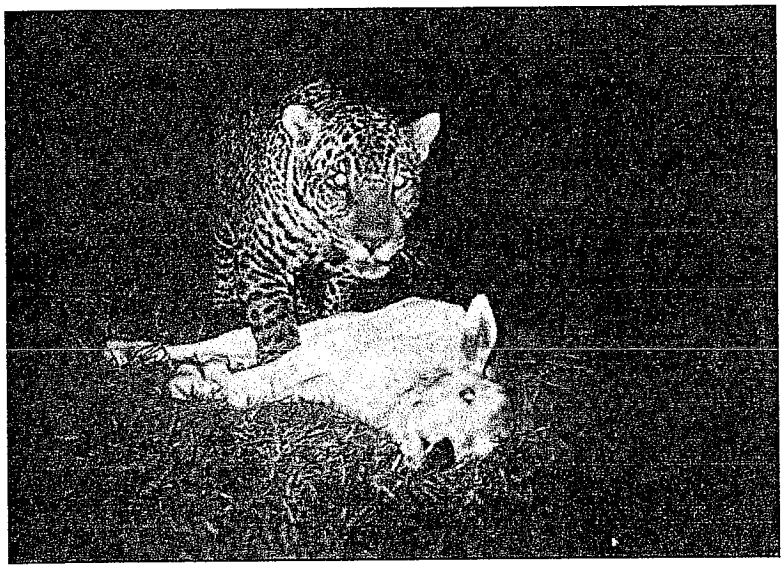

Figure 17.1 A jaguar stands over a young calf that it has killed on a ranch in the southern Pantanal. © Pantanal Jaguar Project archive.

(Fig. 17.2) and abundance have declined drastically in recent decades (Hoogesteijn 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; Hoogesteijn 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 persecution 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

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

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 km^2 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 (Zimmermann 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 $\leq$7.5 cattle/km^2; 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: Scognamillo *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 km^2) and the rainforests of Amazonia (3,400,000 km^2). The southern Pantanal of Brazil has the highest density of jaguars recorded (estimates range from 6.7 to 11.7 individuals/100 km^2; 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 km^2 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

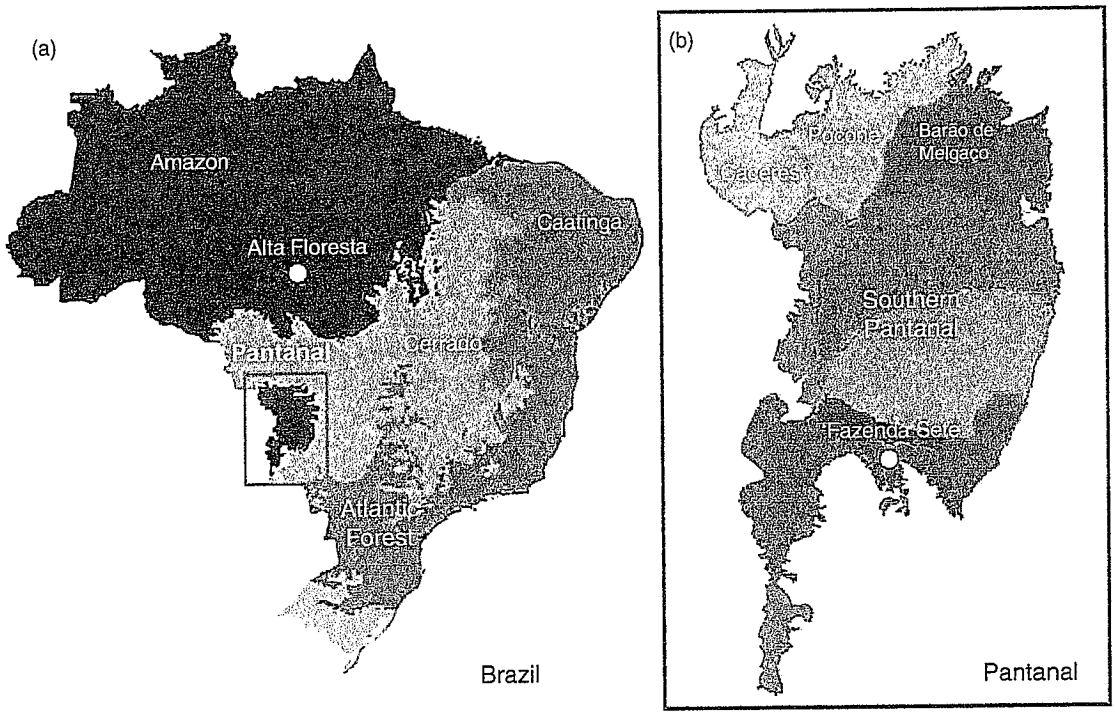

Figure 17.3 (a) Map of Brazil showing major biomes, the Amazon study site (Alta Floresta), and the Pantanal (highlighted by the box); and (b) map of the Pantanal showing its subregions. This study was conducted in the three subregions of northern Pantanal, namely Cáceres, Poconé, and Barão de Melgaço, 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/km^2 (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 example, 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 knowledge 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 cancrivorous*).

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 paraguagensis*; coati; small anaconda *Eunectes notaeus*; and armadillo, *Euphractos sexcinctus and Dasypus 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, Susscrofa; peccary; armadillo; raccoon; or caiman, *Cayman crocodylus yacare*). This 'scavenger-trap' hypothesis seemed inappropriate for the remaining 21% of

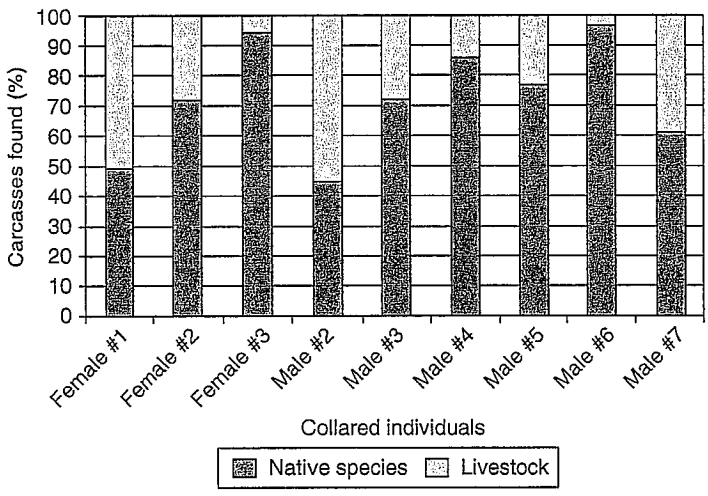

Figure 17.4 Distribution of native prey species and livestock killed by collared jaguars, November 2001 to April 2004, southern Pantanal, Brazil. (From Cavalcanti 2008.)

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.

	Adult female				Adult male					
Prey	#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)	Subadult male #6 (*n* = 27)
Tapir, *Tapirus terrestris*	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
Calf *Bos taurus*	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 *Hydrochoerus hydrochaeris*	4 (5.0)	1 (0.81)	0	0	0	0	0	1 (2.50)	0	3 (11.1)
Marsh deer, *Blastocerus dichotomus*	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, *Chrysocyon brachyurus*	2 (2.50)	1 (0.81)	0	0	0	0	0	0	0	0
Land turtle, *Geochelone carbonaria*	1 (1.25)	0	0	0	0	0	0	0	0	0
Caiman, *Cayman crocodylus yacare*	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, *Cerdocyon thous*	0	1 (0.81)	0	0	0	0	0	1 (2.50)	1 (2.78)	0
Raccoon, *Procyon cancrivorus*	0	0	1 (4.54)	0	0	1 (2.78)	0	0	1 (2.78)	0
Feral hog, *Sus scrofa*	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, *Nasua nasua*	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, *Eunectes noctaeus*	0	0	0	0	0	0	0	0	0	1 (3.70)
Giant anteater, *Myrmecophaga tridactyla*	7 (8.75)	2 (1.63)	0	0	1 (2.13)	3 (8.33)	0	0	1 (2.78)	0
Lesser anteater, *Tamandua tetradactyla*	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, *B. taurus*	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, *Bracaena paraguayensis*	0	1 (0.81)	0	0	0	0	0	0	0	0

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

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

[c] Includes two species of armadillos present in the study area, *Euphractos sexcinctus* (*n* = 4) and *Dasypus 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

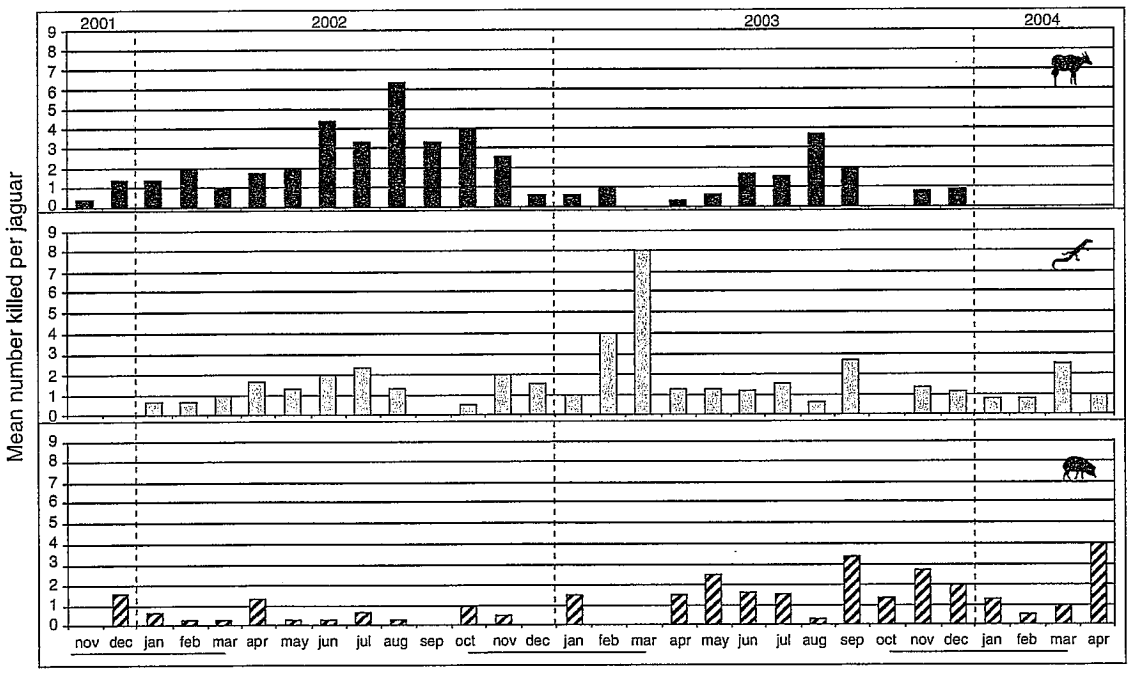

Figure 17.5 Distribution of the mean number of cattle, caiman, and peccary killed per month by collared jaguars, November 2001 to April 2004, southern Pantanal, Brazil. (From Cavalcanti 2008.)

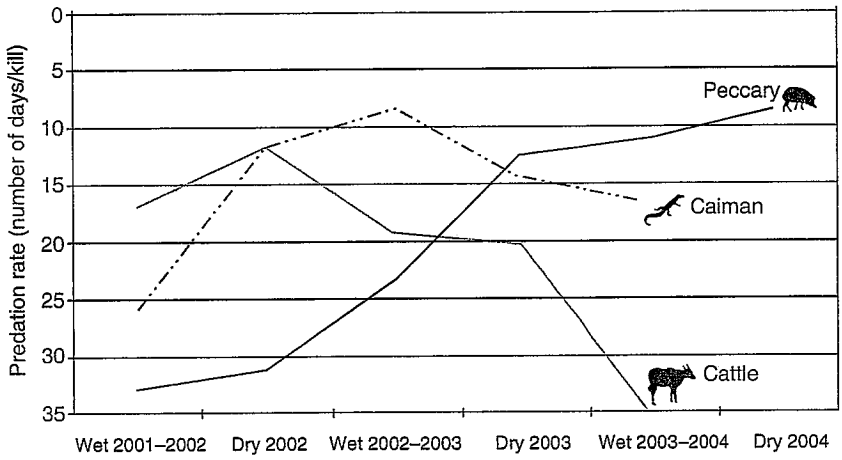

Figure 17.6 Seasonal variation in jaguar predation rates of caiman, peccary, and domestic cattle, November 2001 to April 2004, southern Pantanal, Brazil. (From Cavalcanti 2008.)

peccary densities (9.63 individuals/km^2; 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 domestic 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 km^2; 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

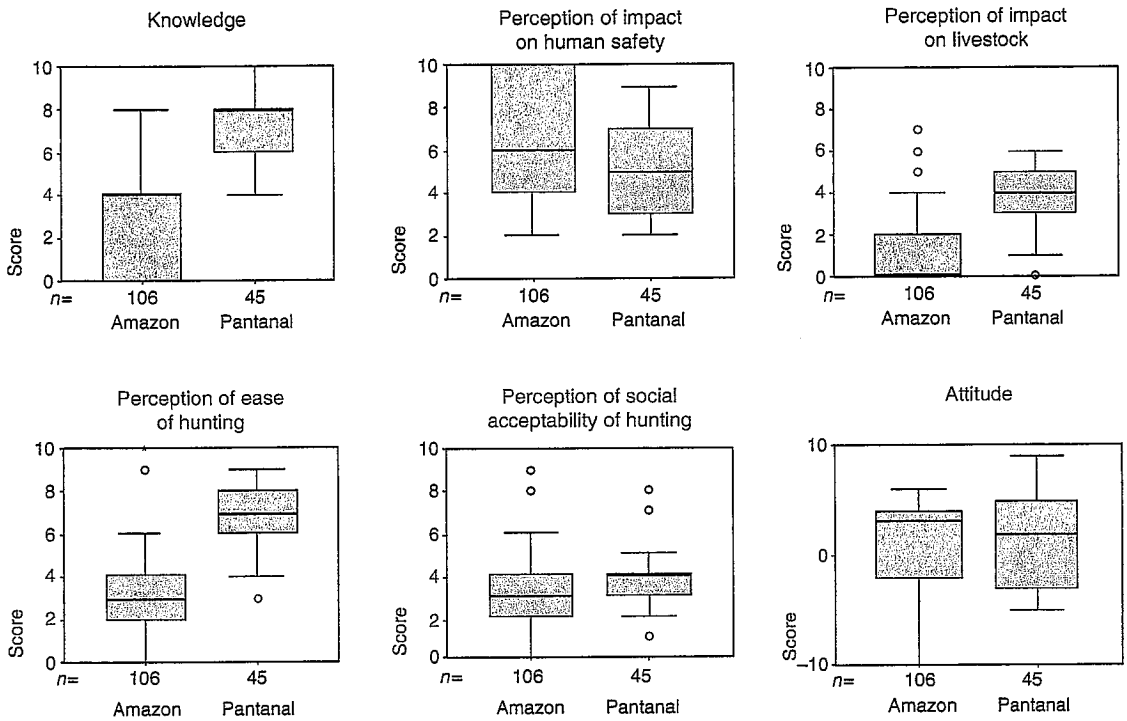

Figure 17.7 Graphs showing the measurement scales, distribution of average score values, and differences between Amazon and Pantanal. The box indicates the median, 25% and 75% quartiles, and whiskers are the largest values that are not outliers, while circles mark outliers.

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 loses (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 increasing 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	Age	1										
2	Years in school	−.50**	1									
3	Property size	.28	.08	1								
4	Knowledge about jaguars and depredation	−.15	−.28	−.17	1							
5	Perception of increase in jaguar abundance	.05	−.12	−.08	.18	1						
6	Perception of decline in economic situation	.43	−.25	.38	.08	.26	1					
7	Perception of impact on human safety	−.08	.27	−.11	−.53**	.45*	.10	1				
8	Perception of impact on livestock	.18	−.49**	−.14	.16	.41**	.47**	.19	1			
9	Perception of ease of hunting jaguars	−.14	.09	−.12	.22	.13	−.11	.13	−.15	1		
10	Perception of social acceptability/ desirability of jaguar hunting	−.10	.19	−.04	−.25	.39	.29	.07	−.18	−.07	1	
11	Attitude to jaguars and jaguar hunting	−.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

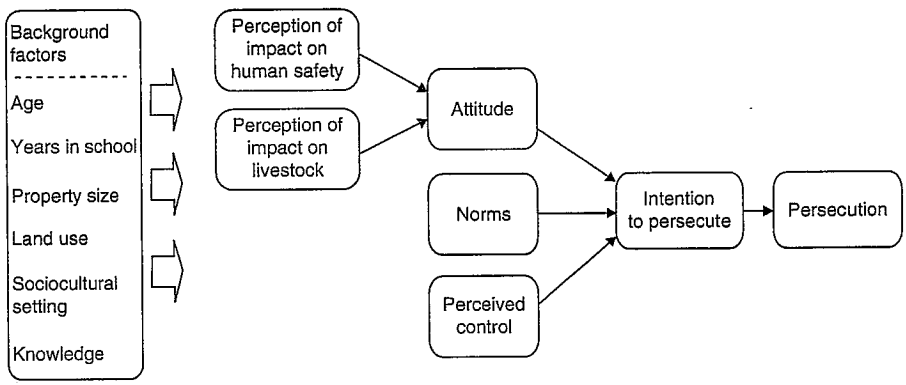

Figure 17.8 Hierarchical cognitive model of jaguar persecution adapted from the Theory of Planned Behaviour (Ajzen 1985).

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.

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