Integrative Zoology 2010; 5: 300-312 doi: 10.1111/j.1749-4877.2010.00218.x

REVIEW

Human–tiger conflict: A review and call for comprehensive plans

John M. GOODRICH

Wildlife Conservation Society, Bronx, New York, NY, USA

Abstract

Human–tiger (*Panthera tigris* Linnaeus, 1758) conflicts (HTC), manifested primarily as attacks on people and domestic animals, exacerbate at least 2 major threats to tigers: (i) conflicts often result in mortality or removal of tigers from the wild; and (ii) they result in negative attitudes towards tigers by local people, thereby reducing support for tiger conservation. Although HTC has decreased over the past century, it will likely increase if current and proposed conservation initiatives to double tiger populations are successful. Increased HTC could undermine successful conservation initiatives if proactive steps are not taken to reduce HTC. The present paper provides a review of the impacts of HTC and the measures taken to reduce it in ways that reduce negative impacts on both humans and tigers, and stresses the need for development and implementation of comprehensive plans to reduce HTC.

Key words: carnivore, depredation, human-tiger conflict, *Panthera tigris*, tiger.

INTRODUCTION

Wherever tigers (*Panthera tigris* Linnaeus, 1758) and people coexist, conflict between the two is likely. Tigers sometimes kill domestic animals or people, and humans often kill tigers in fear, in retaliation and to sell their parts. Such conflicts exacerbate at least 2 major threats to tigers: (i) conflicts often result in mortality or removal of tigers from the wild and are probably second only to poaching as a source of human-caused tiger mortality; and (ii) they result in negative attitudes towards tigers by local people, thereby reducing support for tiger conservation (Gorokhov 1983; Nikolaev & Yudin 1993; Karanth & Gopal 2005; Miquelle *et al*. 2005; Gurung *et al*. 2008; Nyhus & Tilson 2010; Tilson *et al*. 2010). Reducing human-caused mortality is critical to successful tiger conservation because it is usually the primary mortality agent of tigers and tiger populations are in precipitous decline throughout much of their range (Dinerstein *et al*. 2007; Chapron *et al*. 2008; Goodrich *et al*. 2008; Walston *et al*. 2010).

Human–tiger conflicts (HTC) have declined in most areas over the past century as tiger habitat and numbers have declined from roughly 100 000 to only a few thousand individuals (Boomgaard 2001; Nyhus *et al*. 2010). Because there are fewer tigers and less habitat (Walston *et al.* 2010), fewer people live in close proximity to wild tigers, so there is less opportunity for conflict. However, several current tiger conservation initiatives, including programs by international non-governmental organizations, and national tiger recovery plans of many range states, aim to increase tiger populations by 50–100% (e.g. Dalton 2006; Department of Wildlife and National Parks Peninsular Malaysia 2008; Walston *et al*. 2010). If these initiatives are successful, the potential for HTC will increase (Karanth & Gopal 2005). In well-managed protected areas, tigers will enjoy high prey density, little persecution from humans and, consequently, high reproductive rates. Some young tigers will disperse into human-dominated landscapes in search of vacant territories, and some old, wounded and/or diseased tigers will be pushed

Correspondence: John M. Goodrich, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, NY 10460 USA. Email: tiger372@yahoo.com

into these landscapes, often leading to conflict (Karanth & Gopal 2005).

Historically, efforts to reduce HTC focused on lethal control, but as tiger populations declined through the 1900s, efforts began to shift towards managing HTC in ways that reduced risk for both humans and tigers (Treves & Karanth 2003; Nyhus & Tilson 2010). Such efforts are vastly more complex and costly than simply shooting, trapping and poisoning tigers, and require considerable biological, social and political expertise (Treves & Karanth 2003; Woodroffe *et al*. 2005). Perhaps because of this, few comprehensive state-level plans for reducing HTC have been produced and implemented and, in many areas, HTC continues at high levels.

The present paper provides a review of HTC, starting with a definition of HTC and an examination of the impacts of HTC on both tigers and humans. This is followed by a review of conservation-oriented methods for reducing HTC and its impacts. The paper concludes with a call for comprehensive state-level plans for managing THC that include preventive, mitigative and reactionary components with well-defined protocols.

CHARACTERIZATION AND IMPACTS OF HUMAN–TIGER CONFLICT

Human–tiger conflicts can be grouped into 3 categories: tiger attacks on humans, tiger attacks on domestic animals and tigers that approach human-dominated areas (Table 1). Tigers might attack people as prey, but most commonly attack people defensively to protect their cubs or themselves, particularly when wounded by people (McDougal 1987; Gurung *et al*. 2008; Goodrich *et al.* 2010). Tigers usually attack domestic animals as prey, most commonly in areas where wild prey have been depleted (see below). When tigers enter human-dominated areas, it is not a conflict per se, but such events might be a precursor to conflict and receive considerable attention from local people, who often request intervention from government authorities and, hence, are considered HTC (Nugraha & Sugardjito 2009; Goodrich *et al*. 2010). For the most part, this review focuses on the first 2 types of conflict.

Impacts of HTC on human populations are well documented in many areas. Historically (>50 years ago), human deaths were 1 to 2 orders of magnitude greater, with human deaths numbering in the hundreds annually in areas such as the Sundarbans, Singapore and Indonesia (Nyhus *et al*. 2010). More recently, loss of human life is greatest in South Asia, especially the Sundarbans in Bangladesh and India, where dozens of people are killed per year (McDougal 1987; Karanth & Gopal 2005; Gurung *et al*. 2008; Barlow 2009). In Southeast Asia, loss of human life is highest in Sumatra, where between 5 and 10 people are killed per year (Nyhus & Tilson 2004; Nugraha & Sugardjito 2009); less than 1 person is killed per year in all other Southeast Asian countries (McDougal 1987; Kawaneshi *et al*. 2010; Nyhus & Tilson 2010) and Russia (Miquelle *et al*. 2005; Goodrich *et al*. 2010). Although such levels of mortality are low relative to other causes of mortality in human populations, the economic and emotional impact on local communities is considerable and can result in strong negative responses towards tiger conservation (Quigley & Herrero 2005). If tiger populations increase, the number of people killed per year also might increase unless necessary steps are taken to reduce these incidents.

Depredations on domestic animals are the most common type of HTC. Tigers readily kill livestock and dogs in areas where wild prey are depleted, usually due to hunting, habitat degradation and competition with livestock (Madhusudan & Karanth 2002; Miquelle *et al*. 2005; Johnson *et al*. 2006; Wang & MacDonald 2006; Sangay & Vernes 2008; Nugraha & Sugardjito 2009). Typically, livestock make up a very small portion of the tiger's diet and most tigers avoid livestock altogether (Sunquist 1981; Miquelle *et al*. 1996; Stoen & Wegge 1996; Karanth 2003; Andheria *et al*. 2007). However, in extreme situations, losses might reach as high as 12% of local herds and 17% of annual household income (Madhusudan 2003; Wang & MacDonald 2006; Sangay & Vernes 2008), and livestock can make up over 25% of the tiger's diet (Wang & MacDonald 2009).

Both livestock depredations and attacks on humans result in negative impacts on tigers and their conservation, including increased negative attitudes towards tigers, increased mortality through retaliation killing, poaching by local people, and lethal control or removal from the wild by government officials. Local people might take advantage of depredations on domestic animals as an opportunity to poach a tiger when it returns to feed on the carcass of depredated livestock (Johnson *et al*. 2006). Additionally, poachers might pay local people for information regarding livestock depredations because this provides a good opportunity to poach tigers. They might even provide local people with the means (e.g. poison or traps) to kill tigers (Karanth & Gopal 2005; Kawanishi *et al*. 2010). Although there is little published evidence of poaching networks that are linked to HTC, tiger deaths due to retaliation killing are well documented in some areas

(Gorokhov 1983; Miquelle *et al*. 2005; Tilson *et al*. 2010). For example, retaliation killing made up 29.5% of recorded tiger mortalities in Russia from 1970–1990 (Nikolaev & Yudin 1993). Tigers legally killed or removed from the wild in response to conflict can also be high: for example, 2–4 tigers per year in some areas of South Asia and Southeast Asia (Nugraha & Sugardjito 2009; Kawanishi *et al*. 2010; Smith *et al*. 2010). Lethal control made up 23% of mortalities reported in Russia from 1970–1990 (Nikolaev & Yudin 1993). Furthermore, mortality events can have consequences well beyond the loss of individuals. Removal of adult males might result in infanticide by immigrating males and in reduced reproductive rates (Smith & McDougal 1991; Goodrich *et al.* 2008). High mortality of adult female tigers can result in reduced reproductive rates, cub and subadult survival, and population growth rates (Goodrich *et al.* 2008, 2010). Such levels of mortality can be significant and might tip populations towards decline (Kenney *et al*. 1995; Woodroffe & Ginsberg 1998; Chapron *et al*. 2008).

APPROACHES TO REDUCING HUMAN? TIGER CONFLICTS

Several approaches have been used to deal with HTC. They fall broadly into 4 categories: (i) preventative measures, or those designed to stop or to reduce conflict before it occurs; (ii) mitigative measures, or those that attempt to reduce the impacts of HTC after it occurs; (iii) reactive measures, or measures taken to alleviate a specific, ongoing THC incident; and (iv) integrated programs, which are those that form a component of most or all other measures (Table 1). The following section provides a summary and review of each of these approaches. Comprehensive THC programs should include aspects of all 4 approaches.

Preventative measures

Improved livestock management

In most cases, improving livestock management is the most significant action that can be taken to reduce risk of tiger depredation on livestock. Eliminating livestock grazing within the tiger habitat will eliminate depredation on livestock, except in cases when tigers wander into human-dominated landscapes. Tending of livestock by adult herders during the day and avoiding carnivore habitat (e. g. forested and brushy areas) and predator hotspots might reduce livestock depredation by large felines (Rabinowitz 1986; Mordecai *et al*. 2003; Breitenmoser *et al.* 2005; Karanth & Gopal 2005; Miquelle *et al*. 2005). Fenced enclosures for holding livestock at night have been ef-

Table 1 Summary of types of human–tiger conflict, their impacts and recommended interventions

Type of conflict	Frequency	Impact on people	Impact on tigers	Recommended preventative measures	Recommended mitigative measures	Reactive measures
Tiger attacks on people	Common (tens per year in Sundarbans) to very rare (< 1 per year in Laos).	Very high. Loss of human life; associated emotional, economic stress to survivors.	Very high. Tigers killed in retaliation and removed from population by government.	1. Separate people and tigers through zoning and relocation of people. 2. Reduce human-caused injuries to tigers.	Compensation; health and life insurance.	1. Remove habitual maneaters and badly wounded or sick tigers. 2. Radio monitor tigers in repeated defensive attacks or habitual maneaters if removal unacceptable.
Tiger attacks on domestic animals	Most frequent type of conflict; hundreds of attacks per year in some areas.	High. Economic loss up to 17% of annual income.	High. Tigers killed in retaliation and removed from population by government.	1. Separate domestic animals and tigers through zoning. 2. Improve livestock management; reduce numbers. 3. Increase wild prey. 4. Reduce human-caused injuries to tigers.	Incentives programs.	1. Hazing to frighten tiger from area. 2. Capture when hazing ineffective. 3. Remove badly wounded or sick tigers. 4. Rehabilitate and release wounded or sick animals when possible. 5. Release adults onsite whenever possible and radio-monitor. 6. Translocate and radio-monitor.
Tiger approaches human habitations	Common (tens per year); not reported for many areas.	Low. People often deem tiger as a threat.	Moderate. Tigers killed or officially removed.	1. Separate people and tigers through zoning. 2. Improve livestock management.	None.	Same as for depredation on domestic animals.

fective at preventing attacks by tigers and other carnivores (Charudutt 1997; Brietenmoser *et al*. 2005; Frank *et al.* 2005; K. Munawar, Wildlife Conservation Society [WCS] Indonesia Program, pers. comm.), but increase the chances of multiple livestock deaths should a feline get inside the fence (Breitenmoser *et al.* 2005). Vegetative cover around the enclosures might be reduced because tigers avoid open areas. Larger fenced enclosures are generally cost-prohibitive, require extensive maintenance and might inhibit genetic exchange between tiger populations (e.g. if reserves are fenced). Keeping buffalo together with cattle might reduce predation because buffalo act defensively towards predators, but it will not eliminate the problem because tigers might kill buffalo (Karanth & Gopal 2005; Hoogesteijn & Hoogesteijn 2008). Dogs are used to guard livestock against many different predator species (Green *et al*. 1984; Breitenmoser *et al*. 2005), but tigers readily prey on dogs, so the presence of dogs might attract tigers to livestock herds (Miquelle *et al*. 2005; Li *et al*. 2009; Nugraha & Sugardjito 2009; Goodrich *et al*. 2010b). These interventions might represent a significant enough cost to local people that they will not implement them without some kind of technical or financial assistance.

Reducing livestock numbers might help to reduce conflicts, but people are unlikely to voluntarily reduce their livestock herds without significant incentives. The government of Bhutan is considering a program to trade more efficient breeds of cattle for inefficient breeds (e.g. on a "1 for 2" basis), thereby replacing quantity with quality (Nature Conservation Division 2008). In Northeast China, the Wildlife Conservation Society is experimenting with introducing stall-fed cattle, which grow faster and provide greater profits, in place of range-fed cattle (Li *et al*. 2009). However, without enforceable legal restrictions on livestock numbers and grazing zones, in both cases, livestock owners might simply add more cows into grazing lands, resulting in the same or even greater numbers than before the conservation intervention.

Ideally, lands should be zoned to define acceptable grazing lands, with strict enforcement to eliminate livestock from non-grazing zones in critical tiger habitat. As a part of this process, grazing rights should be eliminated in tiger habitat whenever possible. In areas such as Bhutan, where domestic animals make up a significant proportion of tiger diet (Wang & MacDonald 2006; Sangay & Vernes 2008), it is critical to increase wild prey density prior to or concurrently with reductions in livestock. Otherwise, the tiger population might be faced with a decrease in food availability, possibly resulting in increased HTC and decreased survival and reproduction of tigers.

Management of wild prey

Low density of wild prey might result in increased attacks on both livestock and people by tigers (Reza *et al*. 2002; Miquelle *et al*. 2005; Johnson *et al*. 2006; Li *et al*. 2009) and other large cats (Loveridge *et al*. 2010), especially following sharp declines in prey density. Decline in prey densities is an important cause of decline in tiger densities range-wide (Karanth & Stith 1999; Karanth *et al*. 2004). Actions to increase prey populations will be site specific, but might include changes in legislation and improved law enforcement to reduce overharvest, reduction of competition with livestock, and habitat protection and restoration. For example, tiger prey populations were increased by approximately 80% in Nagerhole National Park in India through anti-poaching patrols, limiting human access to the park and resettling villages from inside the park (Karanth *et al.* 1999). Availability of livestock to tigers must be decreased concurrently with interventions to increase wild prey; otherwise, depredations on livestock might increase as tiger density and reproduction increases.

Zoning

Land-use patterns influence HTC and zoning can minimize HTC by removing or better managing conflicting activities (e.g. livestock grazing) (Linnell *et al*. 2005). It is clear that highest levels of conflict occur where tigers and people extensively overlap (Karanth & Madhusudan 2002; Nyhus & Tilson 2004; Smith *et al*. 2010). The goal of zoning is to separate people and their livestock from critical tiger habitats and movement corridors whenever possible, and requires human relocation programs that are transparent, incentive-driven and fair (Karanth & Madhusudan 2002). Removing people and livestock from tiger habitat arrests HTC, can reduce habitat fragmentation and facilitates prey population recovery (Karanth & Gopal 2005; Nyhus *et al*. 2010). Karanth and Gopal (2005) suggest that hard agricultural edges bordering tiger habitat might reduce HTC if the agricultural lands (e. g. coffee or oil palm plantations) have no livestock and human activity is limited to people harvesting and maintaining crops during the day, preferably in groups. However, this must be balanced against the need for dispersal corridors between critical tiger habitats. That is, agricultural lands such as oil palm plantations that form hard edges are a barrier to tiger movement (Maddox 2010); if critical habitats are completely surrounded by such lands, the tiger populations therein will become genetically isolated.

Reducing injuries to tigers

Tigers and other large felines that attack people and livestock are sometimes wounded animals, and the wounds are often caused by snares, traps or gunshot (Gurung *et al*. 2008; Goodrich *et al.* 2010; Loveridge *et al*. 2010). Goodrich *et al.* (2010) found that 77% of the tigers that attacked humans were wounded by humans, usually in poaching attempts. In both Indonesia and China, tigers wounded by snares have killed both livestock and people and >50% of livestock depredating jaguars (*Panthera onca* Linnaeus, 1758) had old human-caused wounds (Rabinowitz 1986; Hoogesteijn *et al*. 1993). Tigers are often captured in snares set for other species, such as those set for wild pigs in Sumatra (K. Munawar, WCS Indonesia Program, pers. comm.). Anti-poaching, snare removal and other efforts that reduce the rate at which tigers are injured will help to reduce HTC.

Other preventative measures

A variety of other measures have been used, particularly in the Sundarbans in Bangladesh, to prevent or thwart attacks on humans (Barlow *et al*. 2010). Masks worn on the back of the head and armored headgear have been used to discourage tiger attacks and electrified mannequins have been used to condition tigers against attacking humans (Sanyal 1987; Mukherjee 2003), but these methods have not been rigorously tested (Karanth & Gopal 2005; Barlow *et al*. 2010). Dogs have been used to warn people of tiger presence (Khan 2009), but in Russia, several people have been attacked by tigers attempting to prey on dogs (Goodrich *et al.* 2010). Handheld flares and pepper spray have been used to successfully thwart attacking tigers in Russia (Goodrich, pers. obsv.).

Programs that mitigate the impacts of human–tiger conflicts

Compensation and insurance programs

Compensation programs provide compensation for losses of livestock to depredation, medical expenses when people are attacked or compensation to a family when a life is lost. Compensation programs usually aim to improve local acceptance of tigers and, thereby, reduce retaliation killing, but with very mixed results (Nyhus *et al*. 2003, 2005). Reasons for failure include unsustainably high payout costs, difficulty in verifying claims, high numbers of false claims, government corruption and the difficulty of making timely payments in rural areas (Madhusudan 2003; Karanth & Gopal 2005; Nyhus *et al*. 2005). For compensation for human deaths, it is difficult and some believe immoral to put a value on human life (Nyhus *et al*. 2010); however, not compensating for loss of human life might create the impression of a conservation community that is extraordinarily indifferent. Furthermore, in most parts of tiger ranges, there are multiple predator species that might kill livestock and humans. Compensating only for damage caused by tigers might not reduce retaliation killing of tigers because methods commonly used for retaliation killing (e.g. snaring, poisoning and explosive traps) are indiscriminate. Nyhus *et al*. (2005) conclude that successful compensation programs include mechanisms for solving all of these problems, as well as monitoring of wildlife populations to demonstrate success.

For these reasons, compensation programs are not recommended for livestock depredation, but if they are used, provide compensation only in cases where, despite good livestock management practices, there is still depredation. Experienced personnel must be employed to investigate all conflicts and ensure that they were caused by a tiger and the livestock were cared for following strict guidelines of the compensation program (e.g. livestock were not grazed in tiger habitat, they were attended by a herder and kept in enclosures at night). However, compensation for human injury or loss of life might have a more positive impact on conservation (Karanth & Gopal 2005; Nyhus *et al.* 2005) and such programs have fewer problems because attacks on humans are rare in most areas and claims are more easily verified.

Insurance programs are subject to similar problems and the further problem of lack of availability of private insurance companies willing to insure against livestock depredation at reasonable prices (Nyhus *et al*. 2005). Where private companies are willing to insure at reasonable rates, the system provides a sustainable mechanism for compensation for depredation by tigers. In Russia, deer farms can insure their deer against depredation through private companies; however, because compensation is not tied to good management practices such as those listed above for livestock, there is no incentive to reduce depredations on domestic animals. Like compensation, insurance payouts must be tied to livestock management practices that minimize depredation.

Incentives programs

Incentives programs attempt to offset costs of depredation by providing alternative sources of income based on "conservation-friendly" practices, which often include improved livestock management practices. The value of incentives programs as tiger conservation tools is unclear because it has never been demonstrated that incentives programs have a positive impact on tiger populations. The WCS-Russia program is experimenting with an incentives program that provides a "tiger-friendly" certification to non-timber forest products collected by wildlife management organizations that demonstrate effective poaching control, environmentally sustainable use of natural resources, fair distribution of economic returns and adequate densities of tigers (Miquelle *et al*. 2005). Incentives programs have also been used for snow leopard conservation in several countries, with a positive response from local communities, increased local incomes and increased density of wild prey (Mishra *et al*. 2003; Jackson *et al*. 2010). All of these programs are subsidized, at least at their outset, but some have become self-sustaining such as those of the Snow Leopard Trust (T. McCarthy, Panthera, pers. comm.). However, because the black-market value of a tiger is very high, it will be difficult to develop incentive programs that offset the potential income gained by poaching tigers.

Reactive measures

Although the aforementioned programs aim to minimize conflict, conflict is still likely to occur where tigers and people coexist. A variety of factors, such as lack of space, disease, injury and senescence, will sometimes cause individual tigers to enter villages and/or attack domestic animals or people (Gurung *et al*. 2008; Goodrich *et al.* 2010). Therefore, wherever tiger populations exist, mechanisms for dealing with individual conflicts are needed. The most common measures used historically and to date are lethal control and removal from the wild, both of which have the same impact on the wild population; that is, reduced survival rates (Karanth & Gopal 2005; Miquelle *et al*. 2005; Treves & Naughton-Treves 2005; Gurung *et al*. 2008; Nugraha & Sugardjito 2009; Boomgaard 2010; Kawanishi *et al*. 2010; Nyhus *et al*. 2010). Both of these methods are necessary for "problem" tigers that, due to injury, disease or infirmity, are not fit to survive in the wild, or, in many cases, for tigers that repeatedly kill people (Karanth & Gopal 2005; Goodrich *et al.* 2010). However, in some cases, tigers are removed from the wild unnecessarily and it is often unclear if the tiger captured or killed was the offending individual. This results in reduced survival rates for wild populations and, therefore, mechanisms are needed for maintaining these animals in the wild (Goodrich & Miquelle 2005b).

A variety of nonlethal methods have been used in response to individual conflicts by carnivores, including visual and acoustical repellents (e.g. fireworks, signal flares, cracker shells, lights and sirens), projectiles (e.g. rubber bullets), protective collars on livestock and conditioned taste aversion (reviewed in Breitmoser *et al.* 2005). Many of these methods are ineffective (e.g. taste aversion; Linnell 2000) and most of these methods are currently not practical in tiger range states because they are expensive (e.g. many automatic audiovisual systems), require high levels of expertise, are dangerous (e.g. rubber bullets) or are not readily available (e.g. rubber bullets and cracker shells).

Measures used in HTC situations include attempting to frighten the tiger from the area (hereafter referred to as "hazing"), and capturing to fit the animal with a telemetry device and release it onsite or translocate it (Goodrich & Miquelle 2005a; Miquelle *et al*. 2005; Barlow *et al*. 2010). Telemetry allows managers to monitor the tiger, providing an early warning if the tiger attempts to approach humans or livestock and providing a means of measuring the success of interventions (e.g. if the tiger survived and was not involved in further conflict) (Goodrich & Miquelle 2005a; Goodrich & Miquelle 2010). Young animals, often orphaned when their mothers are poached, are often assumed to be too young to survive and are captured, but they might sometimes be maintained in the wild through feeding programs, and cubs as young as 7 months have survived without intervention (Goodrich & Miquelle 2005a,b). Usually, animals that require capture are those that cause repeated depredations, are clearly wounded or diseased, or orphaned cubs that are too young or too unfit to survive on their own. Following capture, a variety of actions have been employed, including releasing animals onsite and then attempting to haze them when it appears conflict is eminent, or monitoring them and keeping people and livestock from the vicinity of the tiger (Goodrich & Miquelle 2005b; Barlow *et al*. 2010; Smith *et al*. 2010). Data on hazing and translocation of tigers are anecdotal and little data have been published (Goodrich & Miquelle 2010), so the efficacy of these techniques is unclear and likely site specific. Hazing with signal flares and fireworks has been used in Russia with apparent success when the tiger was within several meters (Goodrich *et al*. 2010), but approaching tigers so closely is usually difficult. Hazing techniques are commonly used on other carnivores (e.g. bears [*Ursus* spp.], wolves [*Canis lupus* Linnaeus, 1758] and coyotes [*Canis latrans* Say, 1823]) with successes (Breitenmoser *et al.* 2005) high enough to warrant further testing on tigers. Tigers involved in THC have been translocated with 50% success ($n = 4$) both with and without rehabilitation in captivity for emaciated or wounded animals (Goodrich & Miquelle 2005). Translocation has been used in response to conflict by leopards (*P. pardus* Linnaeus, 1758), lions (*P. leo* Linnaeus, 1758) and jaguars with generally low (<50%) success rates primarily because animals returned to capture sites and/or continued to cause conflict (reviewed in Breitenmoser *et al.* 2005; Loveridge *et al*. 2010). However, lack of success is likely, in some cases, the result of poorly designed translocations, including translocating animals short distances, releasing into saturated habitats, and/or translocating inappropriate individuals (Hunter 1998). Some translocations of lions with the goal of reintroduction or population supplementation (i.e. not in response to conflict) have been successful (Hunter *et al.* 2007; Trinkel *et al.* 2008), perhaps because they have been well planned and conflict animals have not been targeted.

Decisions to translocate a tiger, release it onsite or remove it from the wild must take into account degree of certainty that the captured animal is the offending animal, characteristics of the individual tiger such as age, sex, physical condition, behavior and residency status, as well as availability of suitable release sites, appropriate equip-

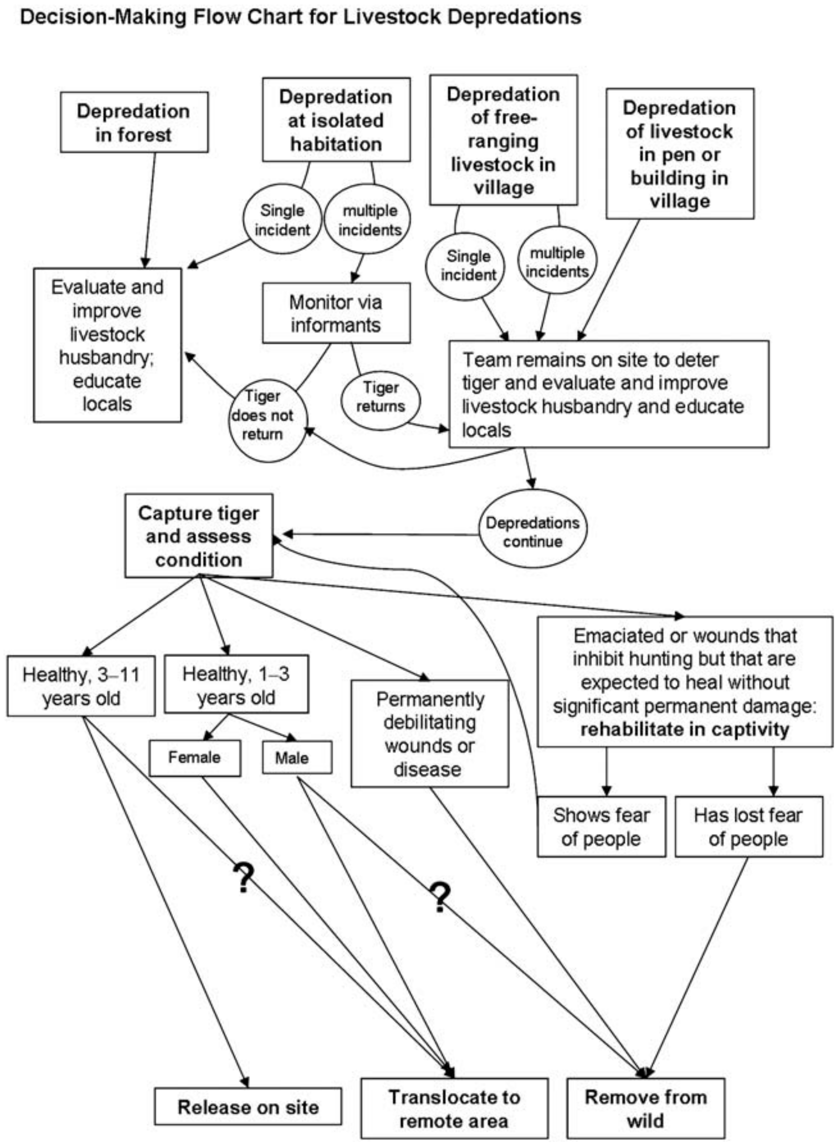

Figure 1 A flow chart representing a decision tree for responding to incidents of tiger depredation on livestock for use by trained "tiger response teams." The chart does not contain all possible combinations of events and outcomes. Rather, it reflects the primary events and outcomes that might be expected in many areas. It is intended as a general example that could be modified and refined for use in specific sites.

ment to capture and transport tigers and holding facilities for captured animals. Photographs, including those from camera traps set at THC sites and genetic data from hair, scat, blood or saliva collected at THC sites can help to identify individuals (Karanth *et al*. 2010). Young, dispersal-age tigers are likely best suited for translocation because these animals would normally be moving through new habitats anyway (Goodrich & Miquelle 2005a; Loveridge *et al*. 2010). Additionally, resident animals at release sites should, presumably, be adapted to intrusion by young animals searching for vacant territories. Priority to maintain an animal in the wild should be given to female tigers over male tigers because females are more important to population persistence (Chapron *et al*. 2008). Physical condition should be evaluated by experienced wildlife veterinarians and/or biologists who would then recommend a course of action (rehabilitate in captivity or not, release onsite, translocate or remove from the wild). Non-resident animals are less likely to return to capture sites and although it is difficult to know residency status in many cases, young (<3 years) animals or those captured far from known tiger habitat are likely to be non-residents. Although for many species, suitable release sites that are not saturated with conspecifics are rare (Loveridge *et al*. 2010), poaching rates of tigers are so high that most existing tiger habitat is unoccupied (Walston *et al*. 2010) and tigers captured in HTC situations could potentially be used to repopulated areas where tiger populations have been decimated by poaching. Suitable traps and transport cages must be used to avoid tooth breakage and other injuries (Karanth & Gopal 2005).

The decision-making process for dealing with HTC events is complex and involves a variety of biological, social and political considerations (Fig. 1). Ideally, a team of trained personnel and an established protocol would respond to individual HTC situations. For example, the Russian Federation employs a "Tiger Response Team," a special team which is part of the State Inspection Tiger Department, charged with dealing with HTC (Miquelle *et al*. 2005). The goal of the team is to reduce losses to human life and livelihood, while minimizing tiger deaths. The team operates under a loosely-defined protocol in response to reports of conflict: (i) investigate and confirm that there was a conflict involving a tiger; (ii) monitor the situation to determine whether the tiger is still in the area and to be available should the tiger cause more conflict; (iii) use hazing techniques (e.g. attempt to frighten the tiger away using signal flares) if the tiger returns; and (iv) capture the tiger and asses its condition if conflict continues or if there is evidence that the tiger is wounded or diseased. Similar teams have recently been employed in Bangladesh (Barlow *et al*. 2010), but few other range states have well-defined protocols or trained personnel dedicated to dealing with HTC. Ideally, tiger response teams would include education, policy and law enforcement (e.g. enforcing grazing policy and anti-poaching laws) in their tool box, as well as techniques for hazing, capture, translocation and radio-monitoring tigers when released after capture.

Tiger response teams should have detailed protocols to aid them in the decision-making process, as illustrated in Figure 1 for depredations on domestic animals. The team first considers the location and frequency of conflict (Fig. 1), with single-event depredations in tiger habitat requiring little intervention on the part of the response team, except to evaluate and encourage changes in livestock management by local people. At the other extreme, repeated depredations on livestock in a corral in a village will require hazing efforts by the team and possibly capture of the offending animal. Once an animal is captured, it should be evaluated by a qualified veterinarian and biologist, to decide whether the animal might be rehabilitated, released onsite, translocated or removed from the wild, based on age, sex and health considerations, and location of the conflict, as discussed above (Fig. 1). Similar flow charts should be made for use when tigers attack people and approach human habitations. The specific details of the flow charts will vary depending on country. For example, in some countries, euthanasia is prohibited, and rehabilitation in captivity and translocation are not options because of lack of capacity.

Integrated programs: Education and community involvement

Most HTC programs will require an education component, which might be presented as part of an overall tiger conservation education program, or as a component of a specific measure to reduce HTC. Education will be an integral part of programs to improve livestock management and compensation, insurance and incentives programs because the latter must be closely linked to changes in human behavior that benefit tigers. Human behavior during an encounter with a tiger can prevent attack, so teaching people about how to respond when confronted with tigers is important (Dunishenko *et al*. 1999). Additionally, people should be taught about laws regarding tiger conservation, and what their rights and responsibilities are relative to HTC.

Human–tiger conflict, by definition, has a direct impact on local communities and, therefore, involvement of local people in HTC management is important and many authors stress community involvement in program development and implementation as a critical aspect of THC programs (Treves *et al*. 2006, 2009; Nature Conservation Division 2008; Barlow *et al*. 2010; Loveridge *et al*. 2010; Nyhus *et al*. 2010; Smith *et al*. 2010). Local involvement in development and management of compensation and insurance schemes might increase acceptance of a scheme (Nyhus *et al*. 2005). For example, one reportedly successful insurance scheme for snow leopard depredation on livestock was community funded and managed, with back-up funds from an ecotourism program (Hussain 2003). Smith *et al*. (2010) promote local involvement in tiger response teams that would capture, equip with telemetry collars and, subsequently, monitor "problem" tigers.

CALL FOR COMPREHENSIVE HUMAN–TIGER CONFLICT PLANS

Comprehensive plans to address HTC that include preventative, mitigative and reactive measures, as well as education and community involvement components, should be developed and implemented by each range state (Table 1). The plans should define what constitutes HTC and formally define the policies and measures that will be taken to address HTC in ways that reduce losses to human life and livelihood and reduce tiger deaths (Nyhus & Tilson 2004; Karanth & Gopal 2005; Miquelle *et al*. 2005). Karanth and Gopal (2005) provide a general framework for development of such plans. The plan should contain several components that focus on dealing with all 3 types of conflict (Table 1). First, the plan should include a system for reporting (e.g. a conflict hotline) and monitoring that will allow for tracking trends in conflict over time and space, thereby identifying conflict "hotspots." Data sheets and a database should be developed that allow for the characterization of conflict, including the location, nature of conflict, number of domestic animals or people wounded or killed, and characteristics (e.g. age, sex and physical condition) of the tiger involved (Nyhus & Tilson 2004; Goodrich *et al.* 2010). Analysis of such data will help to focus and guide HTC interventions. Plans should also conclude a monitoring program to demonstrate success. The ultimate measure of success is stable or increasing tiger populations, with techniques for monitoring tiger populations well-defined (Karanth & Nichols 2010). However, increases in tiger numbers might be the result of other conservation interventions (e.g. anti-poaching activities) and decreases might be the result of other threats (e.g. poaching) so additional measures specific to HTC are also necessary. These should include numbers of domestic animals and humans killed each year and number of tigers killed each year as the result of HTC (i.e. retaliation killing and official killing or removal of tigers from the wild).

Second, the plan should include a strong focus on preventative measures, including detailed interventions for improving livestock management, separating people and tigers (e.g. village relocation and zoning), increasing prey populations where prey are below potential carrying capacity and reducing injuries to tigers (e.g. reducing poaching and snaring). These actions will likely require education, on-the-ground action, and changes in policy and legislation. Third, mitigative measures should be included where applicable, especially those that are closely tied to improved livestock management and encourage or require community involvement in conservation activities. Simple compensation schemes should be avoided. Fourth, the plan should include reactive measures as discussed above, including the creation of a tiger response team if the impact of HTC on people or tigers is high enough to justify such a team. Flexible protocols for responding to specific conflict incidents with decision trees (Fig. 1) to guide assessment of options for conflict resolution (Nyhus & Tilson 2004) should be included. Finally, the plan should include details of HTC-related aspects of education and community involvement programs that should be part of an integrated tiger conservation program. For each step of the plan, it is important to identify or create personnel or positions that will be responsible for each step of the plan, and give those personnel ample authority to carry out their tasks. Specific interventions detailed in the plan will be country and site specific and participatory planning using specific decision-making processes might help to select actions that will best achieve plan goals (Treves *et al*. 2006, 2009; Barlow *et al*. 2010).

Few tiger range states have developed and implemented comprehensive plans for reducing HTC. However, in November 2010, at the Tiger Summit in Saint Petersburg Russia, 13 tiger range countries are expected to commit to doubling the world's tiger population by 2022. With this increase in tiger numbers will come an increase in HTC and it is important that range states proactively take steps to minimize HTC as part of their overall tiger conservation plans. Otherwise, successful conservation initiatives might be reversed as an angry public retaliates in response to increased HTC.

ACKNOWLEDGMENTS

This manuscript was written with the support of the Wildlife Conservation Society. A number of people made helpful comments, both directly and indirectly, on previous drafts: D. Adhiasto, A. Barlow, P. Clyne, C. Greenwood, L. Hunter, A. Johnson, U. Karanth, T. McCarthy, D. Miquelle, K. Munawar, H. Quigley, A. Rabinowitz, G. Schaller and H. Wibisono.

REFERENCES

Andheria AP, Karanth KU, Kumar NS (2007). Diet and prey profiles of three sympatric large carnivores in Bandipur Tiger Reserve, India. *Journal of Zoology* **268**, 169–75.

Barlow ACD (2009). The Sundarbans tiger: Adaptation, population status and conflict management (PhD thesis). University of Minnesota, Saint Paul, USA.

Barlow ACD, Greenwood CJ, Ahmad IU, Smith JLD (2010). Use of an action-selection framework for human–carnivore conflict in the Bangladesh Sundarbans. *Conservation Biology*. doi: 10.1111/j.1523-1739.2010.01496. http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2010.01496.x/abstract

Boomgaard P (2001). *Frontiers of Fear: Tigers and People in the Malay World, 1600–1950.* Yale University Press, New Haven, Connecticut, USA.

Boomgaard P (2010). Tigers and people in the Malay world: Four centuries of confrontation and co-existence in comparative Asian perspective. In: Tilson R, Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 349–56.

Breitenmoser U, Angst C, Landry J, Breitenmoser-Würsten C, Linell JDC, Weber J (2005). Non-lethal techniques for reducing depredation. In: Woodruffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Co-Existence?* Cambridge University Press, Cambridge, UK, pp. 49–71.

Chapron G, Miquelle D, Lambert A, Goodrich J, Legendre S, Clobert J (2008). The impact of poaching versus prey depletion on tigers and other large solitary felids. *Journal of Applied Ecology* **45**, 1667–74.

Dalton R (2006). Doing conservation by numbers. *Nature* **442**, 12.

Department of Wildlife and National Parks Peninsular Malaysia (2008). *National Tiger Action Plan for Malaysia, 2008–2020*. Kuala Lumpur, Malaysia.

Dinerstein E, Loucks C, Wikramanayake E *et al*. (2007). The fate of wild tigers. *Bioscience* **57**, 508–14.

Dunishenko YM, Smirnov EN, Salkina GP, Nikolaev IG (1999). Rules on how people should behave and maintain livestock in areas of tiger habitat in Primorsky Krai. Primorsky Primorsky Krai State Committee for Environmental Protection, Vladivostok, Russia.

Frank LG, Woodroffe R, Mordecai OO (2005). People and predators in the Laikipia District, Kenya. In: Woodroffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK, pp. 286–304.

Goodrich JM, Kerley LL, Smirnov EN *et al*. (2008). Survival rates and causes of mortality of Amur tigers on and near the Sikhote-Alin Biosphere Zapovednik. *Journal of Zoology* **276**, 323–9.

Goodrich JM, Miquelle DG (2005a). Translocation of problem Amur tigers to alleviate human–tiger conflicts. *Oryx* **39**, 1–4.

Goodrich JM, Miquelle DG (2005b). Giving tigers a second chance: Rehabilitation and translocation of problem Amur tigers to alleviate human–tiger conflicts. In: Miquelle DG, Smirnov EN, Goodrich JM, eds. *Tigers of Sikhote-Alin Zapovednik: Ecology and Conservation*. PSP, Vladivostok, Russia, pp. 186–90 (in Russian).

Goodrich JM, Miquelle DG (2010). Tiger telemetry. In: Tilson R, Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 261–73.

Goodrich JM, Miquelle DG, Smirnov EN, Kerley LL, Quigley HB, Hornocker MG (2010). Spatial structure of Amur (Siberian) tigers (*Panthera tigris altaica*) on Sikhote-Alin Biosphere Zapovednik, Russia. *Journal of Mammalogy* **91**, 737-48.

Goodrich JM, Seryodkin I, Miquelle DG, Bereznuk SL (2010). Conflicts between Amur tiger and humans in the Russian Far East. *Biological Conservation* (in press).

Gorokhov GG (1983). The causes of illegal shooting of the Amur tiger. *Redkie Vidy Mlekopitaiuschikh ikh Okhrana. Material 3 Vsesoiuznogo Soveschania. Moscow: IEMEZH RAN I VTO AN SSSR* **3**, 88–9 (In Russian).

Green IS, Woodruff RA, Tueller TT (1984). Livestock-guarding dogs for predator control: costs, benefits and practicality. *Wildlife Society Bulletin* **12**, 44–50.

Gurung B, Smith JLD, McDougal C, Karki JB, Barlow A

(2008). Factors associated with human-killing tigers in Chitwan National Park, Nepal. *Biological Conservation* **141**, 3069–78.

Hoogesteijn R, Hoogesteijn A (2008). Conflicts between cattle ranching and large predators in Venezuela: Could use of water buffalo facilitate felid conservation? *Oryx* **42**, 132–8.

Hoogesteijn R, Hoogesteijn A, Mondolfi E (1993). Jaguar predation and conservation: Cattle mortality caused by felines on three ranches in the Venezuelan Llanos. In: Dunstone N, Gorman ML, eds. Proceedings of a symposium held by the Zoological Society of London and Mammal Society, London; 22-23 Nov 1991, London, UK. Oxford University Press, London, UK, pp. 391–406.

Hunter L (1998). Early post-release movements and behavior of reintroduced cheetahs and lions, and technical considerations in large carnivore restoration. In: Penzhorn BL, ed. Proceedings of a Symposium on Cheetahs as Game Ranch Animals, 23-24 Oct 1998, Onderstepoort, South Africa. Wildlife Group of the South African Veterinary Association, Onderstepoort, South Africa, pp. 72–82.

Hunter L, Skinner JD, Pretorius K *et al.* (2007). Reintroducing lions *Panthera leo* to northern Kwazulu-Natal, South Africa: Short-term biological and technical successes but equivocal long-term conservation. *Oryx* **41**, 196–204.

Hussain S (2003). The status of the snow leopard in Pakistan and its conflict with local farmers. *Oryx* **37**, 26–33.

Jackson RM, Mishra C, McCarthy TM, Ale SB (2010). Snow leopards: Conflict and conservation. In: MacDonald DW, Loveridge AJ, eds. *Biology and Conservation of Wild Felids*. Oxford University Press, Oxford, UK, pp. 417–30.

Johnson A, Vongkhamheng C, Hedemark M, Saithongdam T (2006). Effects of human–carnivore conflict on tiger (*Panthera tigris*) and prey populations in Lao PDR. *Animal Conservation* **9**, 421–30.

Karanth KU (2003). Tiger ecology and conservation on the Indian Subcontinent. *Journal of the Bombay Natural History Society* **100**, 169–89.

Karanth KU, Gopal R (2005). An ecology-based policy framework for human–tiger coexistence in India. In: Woodruffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Co-Existence?* Cambridge University Press, Cambridge, UK, pp. 373–87.

Karanth KU, Madhusudan MD (2002). Mitigating human–wildlife conflicts in Southeast Asia. In: Terborgh J, ed. *Making Parks Work: Strategies for Preserving Tropical Nature.* Island Press, Washington, DC, pp. 250–63.

Karanth KU, Stith BM (1999). Prey depletion as a critical determinant of tiger population viability. In: Seidensticker J, Christie S, Jackson P, eds. *Riding the Tiger: Tiger Conservation in Human-Dominated Landscapes.* Cambridge University Press, Cambridge, UK, pp. 100–113.

Karanth KU, Nichols JD, Kumar NS, Link WA, Hines JE (2004). Tigers and their prey: Predicting carnivore desnites from prey abundance. *PNAS* **101**, 4854–8.

Karanth KU, Funston P, Sanderson E (2010). Many ways of skinning a cat: Tools and techniques for studying wild felids. In: MacDonald DW, Loveridge AJ, eds. *Biology and Conservation of Wild Felids*. Oxford University Press, Oxford, UK, pp. 198–216.

Kawanishi K, Gumal M, Soosayraj LA *et al.* (1995). The long-term effects of tiger poaching on population viability. *Conservation Biology* **9**, 1127–33.

Khan MM (2009). Can domestic dogs save humans from tigers *Panthera tigris*? *Oryx* **43**, 44–7.

Li B, Zhang E, Liu Z (2009). Livestock depredation by Amur tigers in Hunchun Nature Reserve, Jilin, China. *Acta Theriologica Sinica* **29**, 231–8.

Linnell JDC (2000). Taste aversive conditioning: A comment. *Carnivore Damage Prevention News* **2**, 4.

Linnell JD, Nilsen EB, Lande US *et al*. (2005). Zoning as a means of mitigating conflicts with large carnivores: principles and reality. In: Woodruffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Co-Existence?* Cambridge University Press, Cambridge, UK, pp. 162–75.

Loveridge AJ, Wang SW, Frank LG, Seidensticker J (2010). People and wild felids: Conservation of cast and management of conflict. In: MacDonald DW, Loveridge AJ, eds. *Biology and Conservation of Wild Felids*. Oxford University Press, Oxford, UK, pp. 161–95.

Maddox T (2010). The claws of a dilemma: Can big business contribute to tiger conservation in Indoneisa? In: Tilson R, Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 395–402.

Madhusudan MD (2003). Living amidst large wildlife: Livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, South India. *Environmental Management* **31**, 466–75.

Madhusudan MD, Karanth KU (2002). Local hunting and the conservation of large mammals in India. *Ambio* **3**, 49–54.

McDougal C (1987). The man-eating tiger in geographical and historical perspective. In: Tilson RL, Seal US, eds. *Tigers of the World: The Biology, Biopolitics, Management, and Conservation of an Endangered Species*. Noyes, Park Ridge, NJ, USA, pp. 435–8.

Miquelle D, Nikolaev I, Goodrich J *et al*. (2005). Searching for the coexistence recipe: A case study of conflicts between people and tigers in the Russian Far East. In: Woodroffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK, pp. 305–22.

Miquelle DG, Smirnov EN, Quigley HB, Hornocker MG, Nikolaev IG, Matyushkin EN (1996). Food habits of Amur tigers in Sikhote-Alin Zapovednik and the Russian Far East, and implications for conservation. *Journal of Wildlife Research* **1**, 138–47.

Mishra C, Allen P, McCarthy T, Madhusudan MD, Bayarjargal A, Prins HHT (2003). The role of incentive programs in conserving the snow leopard. *Conservation Biology* **17**, 1512–20.

Mordecai O, Woodroffe R, Oguge N, Frank L (2003). Limiting depredation by African carnivores: The role of livestock husbandry. *Conservation Biology* **17**, 1521–30.

Mukherjee S (2003). Tiger human conflicts in Sundarban Tiger Reserve, West Bengal, India. *Tiger Paper* **30**, 3–6.

Nature Conservation Division (2008). Bhutan national human–wildlife conflicts strategy. Nature Conservation Division, Department of Forests, Ministry of Agriculture, Paro, Bhutan.

Nikolaev IG, Yudin VG (1993). Tiger and man in conflict situations. *Bulletin Moskovsky Obschestva Ispytateley Priorody, Otdyel Biologica* **98**, 23–6 (In Russian).

Nugraha RT, Sugardjito J (2009) Assessment and management options of human–tiger conflicts in Kerinci Seblat National Park, Sumatra, Indonesia. *Mammal Study* **34**, 141–54.

Nyhus PJ, Tilson R (2004). Characterizing human–tiger conflict in Sumatra, Indonesia: Implications for conservation. *Oryx* **38**, 68–74.

Nyhus PJ, Tilson R (2010). *Panthera tigris* vs *Homo sapiens*: Conflict, coexistence, or extinction? In: Tilson R, Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 125–42.

Nyhus PJ, Fischer H, Madden F, Osofsky S (2003). Taking the bite out of wildlife damage: The challenges of wildlife compensation schemes. *Conservation in Practice* **4**, 37–40.

Nyhus PJ, Osofsky SA, Ferraro P, Madden F, Fischer F (2005). Bearing the cost of human–wildlife conflict: The challenges of compensation schemes. In: Woodroffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK, pp. 107–121.

Nyhus PJ, Caitlin ED, Ambrogi MC, Hart SE, Caroll C, Tilson R (2010). Human–tiger conflict over time. In: Tilson R, Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 132–5.

Quigley HQ, Herrero S (2005). Characterization and prevention of attacks on humans. In: Woodroffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK, pp. 27–48.

Rabinowitz AR (1986). Jaguar predation on domestic livestock in Belize. *Wildlife Society Bulletin* **14**, 170–74.

Reza AHMA, Feeroz MM, Islam MA (2002). Man–tiger interaction in the Bangladesh Sundarbans. *Bangladesh Journal of Life Science* **14**, 75–82.

Sangay T, Vernes K (2008). Human–wildlife conflict in the Kingdom of Bhutan: Patterns of livestock depredation by large mammalian carnivores. *Biological Conservation* **141**, 1272–82.

Sanyal P (1987). Managing the maneaters of the Sundarbans Tiger Reserve of India: A case study. In: Tilson RL, Seal US, eds. *Tigers of the World: The Biology, Biopolitics, Management, and Conservation of an Endangered Species*. Noyes, Park Ridge, NJ, USA, pp. 427–34.

Smith JLD, McDougal C, Gurung B *et al*. (2010). Securing the future for Nepal's tigers: Lessons from the past and present. In: Tilson R., Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 331–44.

Stoen OG, Wegge P (1996). Prey selection and prey removal by tiger (*Panthera tigris*) during the dry season in lowland Nepal. *Mammalia* **60**, 363–73.

Sunquist ME (1981). Social organization of tigers in Royal

Chitawan National Park, Nepal. *Smithsonian Contributions to Zoology* **336**, 1–98.

Tilson R, Nyhus P, Sriyanto, Rubianto A (2010). Poaching and poisoning of tigers in Sumatra for the domestic market. In: Tilson R., Nyhus PJ, eds. *Tigers of the World: The Science, Politics, and Conservation of* Panthera tigris, 2nd edn. Academic Press, Burlington, MA, USA, pp. 101–12.

Treves A, Karanth KU (2003). Human–carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology* **17**, 1491–9.

Treves A, Naughton-Treves L (2005). Evaluating lethal control in the management of human–wildlife conflict. In: Woodroffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK, pp. 86–106.

Treves A, Wallace RB, Naughton-Treves L, Morales A (2006). Comanaging human–wildlife conflicts: A review. *Human Dimensions of Wildlife* **11**, 1–14.

Treves A, Wallace RB, White S (2009). Participatory planning of interventions to mitigate human–wildlife conflicts. *Conservation Biology* **23**, 1577–87.

Trinkel M, Ferguson N, Reid A *et al.* (2008). Translocating lions into an inbred population in the Hluhluwe-Umfolozi Park, South Africa. *Animal Conservation* **11**, 138–43.

Walston J, Robinson JG, Bennett EL *et al*. (2010). Bringing the tiger back from the brink – the six percent solution. *PLoS Biology* **8**, e1000485.

Wang SW, MacDonald DW (2006). Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation* **129**, 558–65.

Wang SW, MacDonald DW (2009). Feeding habits and niche partitioning in a predator guild composed of tigers, leopards and dholes in a temperate ecosystem in central Bhutan. *Journal of Zoology* **278**, 1–9.

Woodroffe R, Ginsberg JR (1998). Edge effects and the extinction of populations inside protected areas. *Science* **280**, 2126–8.

Woodroffe R, Thirgood S, Rabinowitz A (2005). The future of coexistence: Resolving human–wildlife conflicts in a changing world. In: Woodroffe R, Thirgood S, Rabinowitz A, eds. *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK, pp. 389–405.