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Factors associated with human-killing tigers in Chitwan National Park, Nepal

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ABSTRACT

Human-killing is the ultimate expression of human–tiger conflict. It is a complex issue that needs to be addressed to maintain support for tiger (*Panthera tigris*) conservation in areas where human-killing is prevalent. This research was undertaken to investigate the ecological and sociological aspects of human-killing in the central lowlands of Nepal. We used 28 years of data from human-killing events in Chitwan National Park and the surrounding area to: (1) document the geographic distribution of human-killing incidents, (2) examine ecological variables associated with sites where humans were killed, (3) characterize human-killing tigers, and (4) identify human activities that make people vulnerable to attack. Finally, we use this information to recommend strategies to reduce human–tiger conflicts. Data on human-killing incidents and removal of human-killing tigers were obtained from veterinarian and Kathmandu Zoo records and by visiting the location of each kill with a victim's family member or friend. Thirty-six tigers killed 88 people from 1979 to 2006. Most (66%) kills were made within 1 km of forest edge but equally in degraded and intact forests. An equal number of male and female tigers killed humans and 56% of tigers that were examined had physical deformities. The trend of human deaths increased significantly from an average of 1.2 (±1.2) persons per year prior to 1998 to 7.2 (±6.9) per year from 1998 to 2006. This difference is due primarily to a ten fold increase in killing in the buffer zone since 1998 because of forest restoration. Nearly half the people killed were grass/fodder collectors. Local participation in tiger management and conservation is essential to mitigate human–tiger conflicts. We recommend that villagers be recruited to help radio collar and monitor potentially dangerous tigers, participate in long term tiger monitoring, and attend a tiger conservation awareness program focused on tiger behavior and avoidance of conflict.

1. Introduction

Tigers (*Panthera tigris*), and other large carnivores, often present unique dilemmas to wildlife managers because they kill livestock and humans (Treves et al., 2002; Patterson et al., 2004; Packer et al., 2005; Woodroffe et al., 2005; Kolowski and Holekamp, 2006; Holmern et al., 2007). In contrast, these mammals are increasingly appreciated for their intrinsic

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value and roles in natural ecosystems (Linkie and Christie, 2007). Human-killing has been documented throughout the tiger's range, including the far east of Russia, Southeast Asia, Sunda Islands and South Asia (McDougal, 1987; Miquelle et al., 2005). South Asia, which has the highest densities of tigers (McDougal, 1977; Smith et al., 1987; Karanth et al., 2004), also has the largest number of human-killing cases (McDougal, 1987; Khan, 1987; Singh, 1993; Corbett, 2005). Tigers have two ecological requirements that place them in direct conflict with humans. First, they need large areas of forest habitat (Sunquist, 1981; Smith et al., 1987, 1998), and second, they require abundant large prey (Smith et al., 1987, 1998). Human conversion of wild lands to agriculture has cleared and fragmented tiger habitat. As a consequence, the global land base for tigers has been reduced to <7% of its historical distribution (Dinerstein et al., 2006); three sub-species of tigers have gone extinct (Seidensticker, 1987). Furthermore, habitat fragmentation has distributed tigers into small, isolated populations (Smith et al., 1998) and long term survival of these small units is uncertain. Abundance of large ungulates, the major prey of tigers, determines tiger density (Karanth and Sunquist, 1995, 2000; Karanth and Nichols, 1998; Karanth et al., 2004). For >40,000 years, humans have hunted ungulate species (i.e. mainly deer (*Cervus* spp., *Muntiacus* spp.) and pig (*Sus* spp.) that constitute tiger prey (Corlett, 2007). However, only during the past 100 years have humans competed with tigers for their primary prey to the extent that prey depletion occurred (Karanth and Stith, 1999). Declines in natural prey encourage tigers to feed on livestock and sometimes humans. In response to tiger attacks on livestock or humans, local people are often motivated to persecute, hunt or poison them. Therefore, human–tiger conflict is a major threat to the continued survival of tigers; it reduces their numbers and erodes support for conservation. The goal of this research is to enhance understanding and ultimately recommend strategies to reduce human–tiger conflicts.

Throughout the current range of tigers, reserves have been created and legal protection established to preserve viable populations and prevent extinction. Other large carnivores such as wolves (*Canis lupus*) (Mech, 1995) and Florida panthers (*Puma concolor coryi*) (Maehr and Lacy, 2002; Kautz et al., 2006) have responded favorably to legal protection. The recent increase in tigers outside protected areas in Nepal (Gurung et al., 2006) indicates that tigers are also recovering in some parts of their range in response to conservation interventions. These recovering populations are re-colonizing a rapidly expanding base of community managed forests. However, a result of higher tiger numbers is an increase in confrontations with humans. If tigers are to survive in the wild, managers must develop effective strategies to reduce tiger conflicts with local people.

Until the mid-twentieth century, tigers were distributed continuously across lowland Nepal (Smythies, 1942). Much of this habitat, however, was converted to agricultural land or fragmented by the late 1960s due to the government settlement program (Gurung, 1983). Over the past 35 years, the government actively protected tigers to prevent further decline. For example, a lowland park system was created and further expanded. Additionally, in recent years, community forestry extended conservation beyond park boundaries into buffer zones, defined as a 5 km strip of land surrounding the protected areas (Budhathoki, 2003) and to more distant lowland forests that potentially function as dispersal corridors or even breeding habitat for tigers (WWF, 2002). The Terai Arc Landscape (TAL) project in Nepal was implemented in 2001 as a landscape scale initiative by the Nepalese government to increase the land base for tigers (Smith et al., 1999; Wikramanayake et al., 2004). The goal of this effort is to increase tiger habitat and also benefit local people by restoring the ecological services and economic benefits that these forests provide. As forests in buffer zones and across TAL are restored, tiger numbers outside parks have increased (Gurung et al., 2006). Given the small size of tiger populations within the protected areas, the increase in tigers living and breeding outside protected areas is a step toward long term viability of Nepal's tiger populations. However, as tigers increase, so do human–tiger conflicts. The number of humans killed by tigers has dramatically increased in recent years (McDougal et al., 2005). To date, most information on human-killing in Nepal is based on anecdotal observation (McDougal, 1987). Recognizing the severity of the problem, the TAL-Nepal strategy plan 2004–2014 (HMGN/MFSC, 2004) and the second Nepal Tiger Conservation Action Plan (DNPWC/MFSC/GoN, 2007) identified human–tiger conflict as a major threat to tiger conservation. The success of TAL's goal, to increase tiger habitat and re-establish connectivity among protected areas, will depend to a large extent on mitigating human–tiger conflict. Our study used 28 years of data from human-killing events in Chitwan National Park and the surrounding area to: (1) document the geographic distribution of human-killing incidents, (2) examine ecological variables associated with sites where humans were killed, (3) characterize human-killing tigers, and (4) identify human activities that make people vulnerable to attack. Finally, we use this information to recommend strategies to reduce human–tiger conflicts.

2. Methods

2.1. *Study area*

Chitwan National Park (CNP), situated in south central Nepal (Fig. 1), was established in 1973 as Nepal's first national park. In 1984, it was designated a UNESCO world heritage site (Majupuria and Majupuria, 1998). Initially the Park area was 544 km^2 but it was extended to its present size of 932 km^2 in 1977. The managers created the adjacent Parsa Wildlife Reserve to the east of CNP to make this isolated population as large as possible (Smith, 1984). The Valmiki Tiger Reserve to the south (in India), is adjacent to CNP and these three reserves support one of the largest tiger populations in South Asia (Wikramanayake et al., 1998; Dinerstein et al., 2006; Ranganathan et al., 2008). In 1996, a 750 km^2 buffer zone was created; 55% was agricultural land and 45% community forests (DNPWC and PPP, 2000).

In 1971, when CNP was preparing for official declaration, Chitwan's human population was 183,644. By 2001, the Chitwan District population had increased to 468,699 (DDC Chitwan, 2002) due to high immigration and birth rates. In 1973, when the Park was established, approximately 4000 people were relocated leaving no more settlements inside the Park.

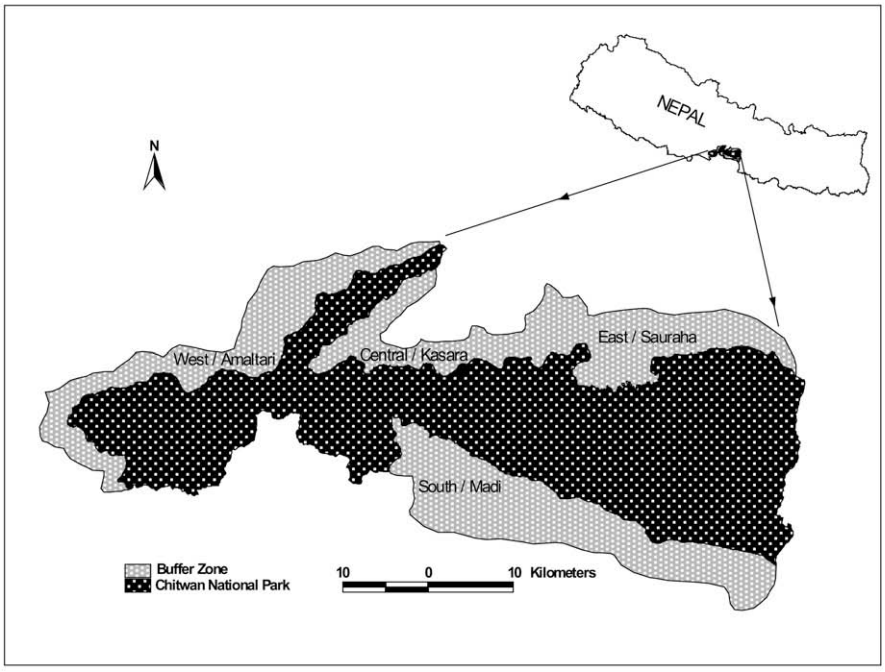

Fig. 1 – A map of Nepal showing the location of Chitwan National Park, the buffer zone and its four management units.

However, in 1999, approximately 223,260 people lived within the buffer zone of the Park. Most of these people depend on agriculture and their livestock contribute to crop production in important ways. For example, farmers depend on livestock manure for fertilizer, draught power for tilling and as important sources of food and protein. Therefore, access to the forest for grazing, lopping of tree branches for fodder, collection of fuel-wood and non-timber forest products are important components of daily life in this region (Shivakoti et al., 1999).

2.2. *Mapping the geographic distribution of kills in relation to ecological variables and temporal periods*

To determine the geographic distribution of tiger kills, we examined records from the Long Term Tiger Monitoring (LTTM) project (Tiger Tops, Nepal), the National Trust for Nature Conservation (NTNC), and data collected by park staff over 35 years. We verified where kills occurred by visiting each victim's family members, close relatives, or other individuals present at the time of the attack. These corroborators accompanied us to the attack sites where we recorded GPS locations. We also used these data to obtain information on the location of tigers that were captured. We verified locations by revisiting these places with technicians from LTTM and NTNC who originally removed the problem animals.

We estimated habitat conditions at kill and capture sites based on the relative abundance of prey. Surveys of prey abundance were obtained at four time periods: 1978–79, 1997, 2001–02, 2005–06 (Smith, 1984; Joshi, unpublished data; Shrestha, 2004; Gurung, unpublished data). These data were used in this study. Habitat quality in a given year was calculated by interpolation of prey abundance data from surveys conducted before and after the kill date. Interpolation was a reasonable approach because abundances were stable from 1978 to 1996 (no interpolation needed) or increased monotonically outside the Park after 1996; in this case, interpolation was a reasonable approach. Relative prey abundance was estimated as sambar units (SU) by converting all prey into equivalent biomass of sambar deer (*Cervus unicolor*), habitat with <3.0 SU was classified as degraded and intact had >3.1 SU (Shrestha, 2004). Distance from the forest edge and Park boundary to kill sites was measured using Arc View 3.3 and 3.8b extension (Jenness, 2007) to determine the zone where kills were most likely to occur.

After examining the kill data, we divided the data into two time periods. From 1979 to 1997 was the period prior to intensive community forestry activity. From 1998 until 2006, forest restoration was widespread in the buffer forests around Chitwan National Park. During this latter period, livestock grazing in buffer zone forests was stopped and forest biomass and prey abundance began to increase in the buffer zone forests.

2.3. *Characteristics of human-killing tigers*

Characteristics of human-killing tigers that were recorded included sex, age, physical condition, number of human victims, and tiger behavior towards humans who retrieved the bodies of victims. Sex and age were determined from track measurements (McDougal, 1999) or examination of dead or captive animals. Female reproductive status was based on the co-occurrence of cub tracks with an adult female or from direct observations of the cubs. For management purposes, the Department of National Parks and Wildlife Conservation (DNPWC) classified human-killing tigers in two categories: one time killers or serial killers. We also used the DNPWC classification of tigers as "aggressive" to describe animals that

failed to leave a victim when humans attempted to retrieve the body.

2.4. *Human activities*

Information about the attacks included victim's name, gender, age and activity at the time of attack as well as date and time of day. This information was obtained during interviews with the victim's families and friends. Kill time was categorized into five periods: morning (0600–0900), forenoon (0900–1200), afternoon (1200–1500), evening (1500–1800) and night (1800–0600). Seasons were divided into summer (15 February–15 June), monsoon (15 June–15 October) and winter (15 October–15 February). Victim activity between gender, season and kill time was compared among groups using χ^2 tests.

3. Results

3.1. *Geographic distribution of humans killed in relation to habitat and forest edge*

During 1979–2006, 88 humans were killed by tigers in and adjacent to CNP (Table 1; Fig. 2). Nearly an equal proportion of people were killed inside (49%) and outside (51%) the Park. However, there was a shift in rate of killing from inside the Park to outside of the Park over time. From 1979 to 1997, tigers killed humans at an average of 1.2 persons/year (SD = 1.2, median = 1) and kills increased significantly to <7.2 kills/year (SD = 6.9, median = 6) for the period 1998–2006 ($F = 13.57$, $df = 26$, $p < 0.001$; Table 2; Fig. 3). The rate of killing per year increased 289% inside the Park; outside the Park it increased 925% (Table 2).

Approximately 66% of all kills were made within 1 km of a forest edge (Fig. 4). Kills were made almost equally in degraded (55%) and intact habitats (45%), but a majority of kill sites (85%) classified as intact habitat was in the Park. In contrast, 81% of kill sites classified as degraded habitat occurred in the buffer zone forests.

Table 1 – Number of people killed by tigers in and adjacent to Chitwan National Park, Nepal, 1979–2006

Year	Park	Buffer zone	Total
1979	0	1	1
1980	3	0	3
1981	2	0	2
1982	0	0	0
1983	0	1	1
1984	1	2	3
1985	1	0	1
1986	3	0	3
1987	1	0	1
1988	2	0	2
1989	0	0	0
1990	0	0	0
1991	0	0	0
1992	0	3	3
1993	1	0	1
1994	0	0	0
1995	0	0	0
1996	1	1	2
1997	0	0	0
1998	5	1	6
1999	1	4	5
2000	0	0	0
2001	8	10	18
2002	1	1	2
2003	3	3	6
2004	5	14	19
2005	4	4	8
2006	1	0	1
Total	43	45	88

3.2. *Distribution and characteristics of human-killing tigers*

Twenty-five tigers (17 human-killing tigers and eight that threatened people) were removed in and adjacent to CNP from 1979 to 2006. Removals of "problem tigers" increased

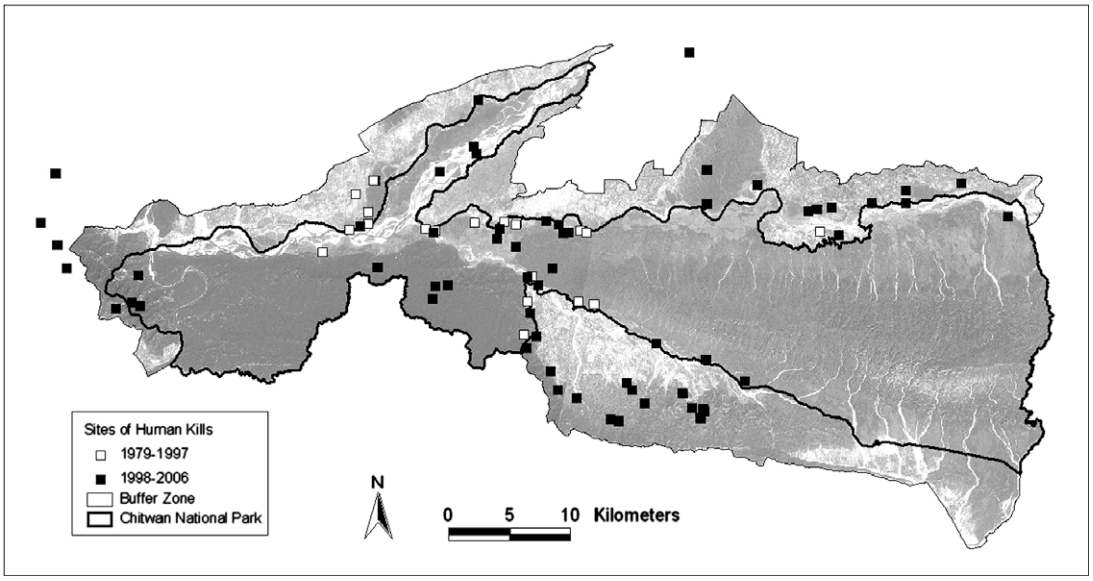

Fig. 2 – Locations of humans killed in and adjacent to Chitwan National Park from 1979 to 1997 and from 1998 to 2006.

Table 2 – The total number and rate/year of human-killing inside and outside Chitwan National Park from 1979 to 1997 (19 years) and from 1998 to 2006 (9 years)

	1979–1997	1998–2006	Percent increase
Outside of Park	8 (0.4/yr)	37 (4.1/yr)	925
Inside the Park	15 (0.8/yr)	28 (3.1/yr)	289
Total	23 (1.2/yr)	65 (7.2/yr)	500

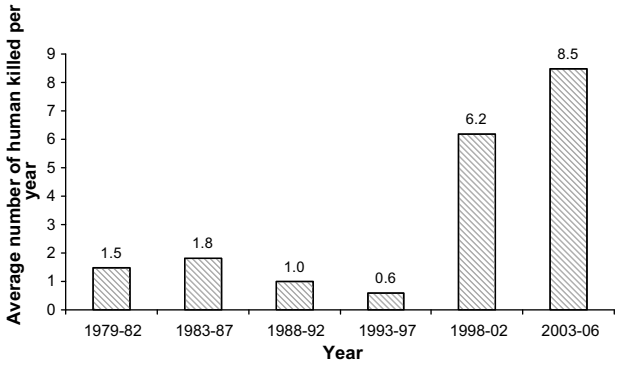

Fig. 3 – Average number of humans killed per year by tigers in and adjacent to Chitwan National Park, 1979–2006.

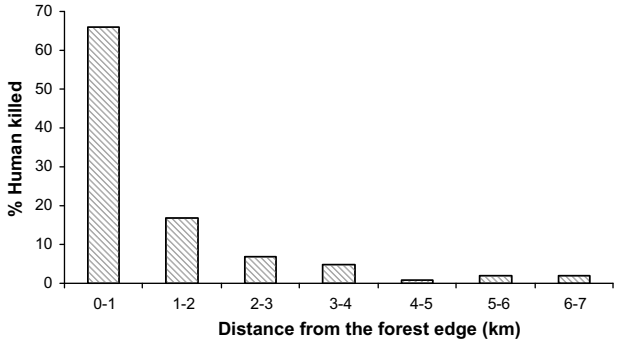

Fig. 4 – Percentage of humans killed in relation to forest edge in and adjacent to Chitwan National Park, 1979–2006.

from 0.4 tigers/year in the 19 year period from 1979 to 1997 to 1.9 tigers/year from 1998 to 2006. Overall, 17 tigers (68%) were removed from the buffer zone and eight (32%) from the Park. Among the tigers removed, 60% ($n = 15$) were killed, 24% ($n = 6$) were captured and put into captivity, and 16% ($n = 4$) were captured and released at different locations inside the Park. The decision on tiger deposition was arbitrary, often depending on whether there was room for an additional tiger at the Kathmandu Zoo. One of the released tigers continued to kill humans in a new area and was subsequently killed. The other three translocated individuals disappeared.

Thirty-six tigers killed a total of 88 people (Table 3). Table 4 summarizes the sex ratio, physiological condition, habitat characteristics and deposition of these human-killing tigers. A nearly equal proportion of males and females were human-killers. Five of 16 females had cubs when they killed humans. Ten of 18 tigers that were examined had physical impairments including age related factors (e.g. damaged and missing teeth); injuries caused by fights with other tigers, and gunshot wounds. Nearly two thirds (61%) of human-killing tigers, including nine of the 10 impaired individuals, were located in degraded habitats. Park managers killed, captured and relocated, or captured and placed in the Kathmandu Zoo, 17 of the 36 human-killing tigers (Table 4).

From a management perspective, the DNPWC classified tigers into one time and serial killers. Seventeen tigers (47%) killed only one person; no action was taken on 11 of these tigers and there were no subsequent kills. The other six tigers were killed because the DNPWC deemed them to be a problem (e.g. two killed people in their house; one killed a person near a large town; one was badly injured; one was associated with a habitual human-killing tiger, and one was aggressive when authorities tried to retrieve the victim's body.

Nineteen tigers that killed two or more persons were classified by DNPWC as serial human-killers (Table 3). They killed a mean of 3.7 people (range 2–7). Eleven serial human-killers were removed; 10 were captured by Park staff and one was poisoned by local villagers. Park staff and wildlife technicians were unsuccessful in removing one of the serial killers that killed five people. Five of the other seven serial killers only killed inside the Park and no action was taken. A sixth tiger killed two people on a single occasion in the buffer zone at the edge of the Park; again, no action was taken because its territory was inside the Park. The seventh serial killer was likely poisoned by local people; the body was never recovered and the tiger did not kill any more people.

Tigers usually leave a human kill when people come to claim the body, but two animals refused to relinquish their victim even when domestic elephants and their handlers attempted to drive the tiger away. A third tiger killed five people within a few minutes and then sat for several hours under a tree into which the sixth person climbed. All three of these animals were classified as aggressive tigers and were captured. These individuals were sub-adults with no disabilities and they were living in intact habitats (Table 3).

3.3. *Characteristics of humans and their activity when killed*

The average age of humans killed was 36 years ($n = 74$); the youngest victim was a 4 year old girl killed at her home. The oldest was a 70 year old man who was killed collecting fodder in the buffer zone forest. More males (60%) than females were killed. The activity of men and women differed significantly at the time of attack ($df = 7$, $p < 0.007$) (Fig. 5). Nearly half the kills occurred when people were collecting grass or fodder for their livestock. This is primarily a woman's task and women were killed more often while collecting fodder ($\chi^2 = 10.67$, $df = 1$, $p < 0.001$); only men were killed while herding livestock, walking in the forest or disturbing tigers at their kills. Tigers killed three people sleeping at their house and two were killed using the toilet outside. There was no seasonal pattern to kills ($\chi^2 = 2.10$, $df = 2$, $p = 0.349$), nor was there a significant time of day when people were killed ($\chi^2 = 4.36$, $df = 3$, $p = 0.225$).

Table 3 – Sex, age class, number of victims, disposition, physical condition, habitat occupied, response to humans investigating kill, and reproductive status of human-killing tigers in Chitwan National Park during the period 1979–2006

Tiger ID	Kills	Sex	Age	Disposition	Impaired	Habitat	Remarks
Parasi	1	F	Adult	No Action	UK	Degraded	
Ujeli	1	F	Adult	No Action	UK	Degraded	With cubs
Bhimle	1	F	Adult	No Action	UK	Intact	
Kumrose P	1	F	Adult	No Action	UK	Degraded	
Baghmara	1	F	Old	Zoo	Yes	Degraded	
F118	1	F	Sub-adult	Killed	No	Intact	Aggressive
Syaulibas	1	F	Sub-adult	Zoo	Yes	Degraded	
Kujauli	1	M	Adult	No Action	UK	Intact	
UK B	1	M	Adult	No Action	UK	Degraded	
M119	1	M	Sub-adult	Zoo	Yes	Degraded	
Bachcha	1	M	Sub-adult	Zoo	No	Intact	Aggressive
Nagarban	1	M	Sub-adult	Relocated	No	Degraded	
UK1	1	UK	UK	No Action	UK	Intact	
UK2	1	UK	UK	No Action	UK	Degraded	
UK3	1	UK	UK	No Action	UK	Intact	
UK4	1	UK	UK	No Action	UK	Degraded	
UK5	1	UK	UK	No Action	UK	Degraded	
Kantipur	2	F	Adult	Poisoned	Yes	Degraded	
Majurtika	2	F	Adult	No Action	UK	Degraded	
UK P	2	F	Adult	No Action	UK	Intact	
Tamor	2	F	Adult	Relocated/killed	Yes	Degraded	With cubs
Bankatta	3	F	Adult	No Action	UK	Intact	
Chepte	3	F	Adult	Killed	No	Degraded	With cubs
Amp	4	F	Adult	No Action	UK	Intact	
Bhagedi	5	F	Adult	Killed	No	Intact	With cubs
Ayodhyapuri P	5	F	Adult	No Action	UK	Degraded	With cubs
Kasara	2	M	Old	Killed	Yes	Degraded	
Madi	2	M	Adult	No Action	UK	Intact	
Bange	3	M	Adult	Zoo	Yes	Degraded	
Kanchha	3	M	Old	Killed	Yes	Degraded	
M127	4	M	Adult	No Action	No	Intact	
Sitalpur	5	M	Sub-adult	Killed	No	Degraded	
Kumrose B	5	M	Sub-adult	Avoided capture	UK	Degraded	
Nuna	6	M	Old	Killed	Yes	Intact	
Ayodhyapuri B	6	M	Sub-adult	Killed	No	Intact	Aggressive
Daunne	7	M	Adult	Killed	Yes	Degraded	

P.S: M = male, F = female, UK = unknown.

Table 4 – Summary of human-killing events: tiger sex and condition, habitat quality, and management action

Category				
Sex	15 males	16 females		
Condition	10 impaired	8 not impaired		
Habitat quality	22 degraded	14 intact		
Management action	10 no action	16 captured[a]	1 relocated	1 avoided capture

a 11 killed, 5 placed in Zoo.

4. Discussion

4.1. *Temporal and geographic distribution of humans killed by tigers*

Between early (1979–1997) and recent (1998–2006) periods, there has been a significant increase in human deaths by tigers in the buffer zone of CNP. We suggest an explanation for the increase. The distribution map of human deaths indicates tigers are using buffer zone habitats more frequently in recent years as compared to about 20–30 years ago. In the early period, forests adjoining the Park were degraded and tigers did not use them often (C. McDougal and J.L.D. Smith pers. comm.). During these years, livestock occasionally supplemented wild prey when tigers explored the degraded forests outside the Park where livestock grazed freely (Sunquist, 1981); however, the situation changed in 1996 when buffer zone community forests surrounding the Park were established (Heinen and Mehta, 2000). By 1998 these forests began to regenerate in response to strict protection by community user groups. Due to these efforts, degraded forests in the buffer zone outside the Park have recovered

(Straede et al., 2002), restoring habitat for tigers and other wildlife. Because livestock grazing is no longer permitted in these forests, both forest and wild prey biomass have increased and these forests have become more attractive to tigers dispersing from CNP. Gurung et al., (2006) documented tigers breeding outside protected areas for the first time since the 1950s. At the same time, human activity in community forests is still relatively high as people now come to the restored forests to cut fodder for stall feeding livestock that formerly grazed in these forests.

Currently, tigers use the buffer zone forests more frequently than 2–3 decades ago and this increased use has resulted in increased human-killing as well as increased human–tiger conflicts such as livestock killing and tigers entering agricultural areas. Park staff are sensitive to human–tiger conflicts in the buffer zone and remove animals they identify as "problem tigers" because these animals repeatedly kill livestock near human habitation or enter agricultural areas. Tigers residing in the Park are not considered "problem tigers" until they kill a human.

Despite an increased land base for tigers outside the Park created by community forestry, there is slim potential for dispersal beyond the Chitwan buffer zone to Bardia, the nearest tiger population 250 km west of Chitwan. Gurung et al. (2006) identified a strong barrier to tiger dispersal between these reserves that was composed of a wide zone of low prey density (Shrestha, 2004) with a narrower belt of urban land near Butwal (Smith, 1993). Even if dispersal corridors were re-established this would not reduce human–tiger conflict in the buffer zone. This conflict is a consequence of increased wild prey in the buffer zone. Therefore, it is essential that managers address the issue of human-killing tigers within the context of the Park and buffer zone. Increasing habitat outside the Park is one objective of the TAL-Nepal strategy plan 2004–2014 (HMGN/MFSC, 2004) designed to increase tiger population sizes. However, rising numbers of humans killed by tigers is an unforeseen consequence of the rapid regeneration of forests to community forest management. Without programs to address the increase in human–tiger conflicts, the negative impacts of human-killers on the well being of local people will likely decrease local support for tiger conservation.

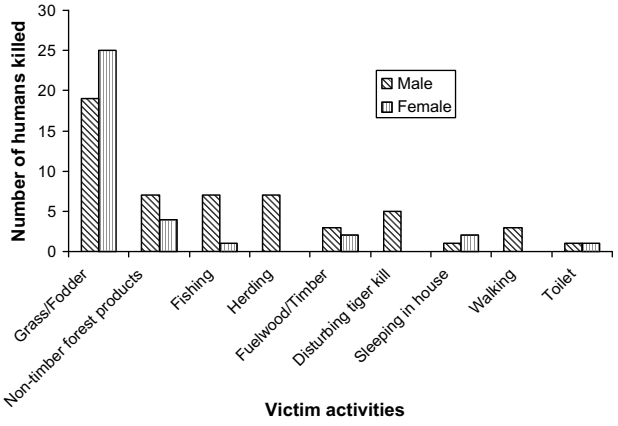

Fig. 5 – Comparison of male and female human activities when killed by tigers between 1979 and 2006 in and adjacent to Chitwan National Park.

During 2001 and 2004, more people were killed by serial human-killers than in other years. In 2001, five tigers killed 18 people; three were serial killers that each killed 4–7 people (16 total). Similarly, in 2004, five of the seven tigers that killed 19 people were serial killers. The high variance in kills among years reflects the stochasticity of the small sample size of tigers; despite high variance there is a clear trend in increasing number of kills after community forestry was implemented. The median number of humans killed per year during the first period was one compared to a median of six in the second period.

This study found most human deaths occurred within 1 km of the forest edge. Tigers killed more humans within this 1 km zone because human use of the forest within this zone is higher than in the forest interior. Similarly, all tigers that came into villages were impaired and killed people that they encountered near the forest edge. Woodroffe and Ginsberg (1998) also reported conflict with humans on reserve borders. They suggest it is a major cause of carnivore mortality worldwide and defined border areas as population sinks. Nyhus and Tilson (2004), likewise, found increased tiger attacks in sub-optimal habitats near forest edges in Sumatra.

4.2. *Characteristics of human-killing tigers*

In Chitwan, we identified occupation of degraded habitat, physical impairment, and aggressiveness towards humans as factors that may have predisposed tigers to kill people. Occupation of degraded habitat and inability to hunt and kill natural prey were the most frequent factors associated with human-killing tigers. Sixty one percent of all human-killers occupied degraded habitats where natural prey was in low abundance. Hunger may have driven those tigers to kill humans. Two females with large cubs that lived in degraded habitats were serial killers. Reduced availability of natural prey combined with the increased food demands of a female raising large cubs may have been a factor in these cases. Large cubs require almost an equal amount of food as adults (Ackerman et al., 1986) and thus these females were feeding the equivalent of 3–5 adult animals. Tigers impaired due to old age and injury may have difficulty defending their territories in intact habitat and are forced into degraded and marginalized areas by tigers in good health (Sunquist, 1981). Impaired tigers forced into degraded habitat may attack humans as an alternative to natural prey (Corbett, 2005). In the famous case of the "man-eaters of Tsavo", two lions killed 135 people during a nine month period. These animals were found to have dental impairments that reduced their ability to kill wild prey so they shifted to humans (Neiburger and Patterson, 2000; Peterhans and Gnoske, 2001).

The final factor related to human-killing was unusual aggressive behavior. Three tigers were judged as aggressive because they would not leave human kills when people came on elephants to retrieve the victims. When captured, these tigers did not have any physical impairment and they lived in areas with a high prey base. These tigers were independent, dispersing sub-adults trying to establish their own territories (McDougal, 1977; Smith, 1993). Such animals move through

occupied territories where they are vulnerable to aggression from resident adults (Smith, 1993). Furthermore, when these animals disperse into degraded habitat and prey on domestic livestock, they are also harassed by villagers who drive them from domestic livestock kills before they have finished feeding. Due to aggressive encounters with tigers and human harassment, we hypothesize these tigers may become aggressive towards humans and ultimately killed people in response to disturbance rather than hunger.

4.3. *Human characteristics and activities*

There were gender differences in the activities people were engaged in when killed. For example, more females than males were killed while collecting fodder because women are the primary gender that rears livestock, including gathering of fodder. In contrast, only males were killed herding livestock, walking in the forest or disturbing tiger kills. Data from Chitwan and a similar data set on human-killing lions in Uganda and Tanzania provide interesting comparisons (Treves and Naughton-Treves, 1999; Packer et al., 2007). In all three situations, male humans were killed more often than females. This male bias reflects the fact that males spend more time in the forest hunting in Uganda and Tanzania or herding in Nepal. In Nepal, men were also killed further into the Park interior than women. In five cases, men were killed because tigers were disturbed at their kills. In three of these cases, men were killed when pirating tiger kills for meat; in the two other cases, men went to check on their livestock. One of these men was killed in tall grass where he discovered a tiger feeding on his ox; the other was killed when he went to his cattle shed to investigate an unusual sound. The tiger had entered the shed and was feeding on a buffalo.

More than half the people killed by tigers in and adjacent to CNP were grass or fodder collectors. Collecting fodder for livestock is one of the important forest activities for farmers in Chitwan (Shivakoti et al., 1999). Fodder collection may have been more intensive in recent years due to grazing restrictions in the buffer zone community forests. Furthermore, grass cutting requires people to sit or bend down. A person in such a posture in dense vegetation may resemble natural prey (Seidensticker and McDougal, 1993). Additionally, fodder collection requires people to enter dense vegetation where succulent foods preferred by livestock are located. Entering such areas holds a higher risk of encountering tigers that are resting during the day.

5. Recommendations

The current policy of DNPWC is more restrictive than the recommendations of Karanth and colleagues (Karanth and Madhusudan, 2002; Treves and Karanth, 2003) who suggest that the only effective option for managing a human-killer is to eliminate the animal by killing or permanently removing it to a captivity. DNPWC only removes tigers that kill people in human settlements or animals that kill more than one person. They also remove tigers that are aggressive towards people that come to retrieve a victim. From 1979 to 1999, five human-killing tigers were captured and placed in the Kathmandu Zoo. Since 1999, however, there has been no room for tigers in captivity so tigers deemed dangerous have been killed. To supplement this policy, we make the following recommendations which we believe have broad application to other human-killing situations involving tigers or lions.

5.1. *Local participation in radio collaring potentially dangerous tigers*

Wildlife officials in Nepal have proposed radio collaring tigers that are not impaired in order to separate people and human-killers. The concept is to engage local people to participate in tracking problem animals and, on a daily basis, create a "no-go" zone around the tiger. This policy was attempted for a female with three cubs that killed five people in a buffer zone forest adjacent to the Park. DNPWC staff suspected the female was healthy and decided to dart her. If she was not impaired, the plan was to radio collar her and create a team of village wildlife technicians to radio monitor the tigress under supervision of a Park ranger. This team would then inform people where the tigress was located and which area to avoid. The idea was not implemented because the female died during capture. We recommend that the DNPWC continue to implement this policy both to immediately reduce threats to humans and also to learn more about the behavior of human-killers to help develop a comprehensive set of responses. Daily monitoring of tigers will create strong pride in local management and reduce potential poaching.

In Kenya, a very successful local participatory management approach was implemented based on the Nepal policy (Hazzah, 2006; Frank et al., 2007). Masai Moran (warriors) monitored potential problem lions (*Panthera leo*) to learn about their movements and behavior to avoid conflict between lions and humans. Continuing to develop this approach of dealing with human-killers in Nepal will build on Nepal's theme of participatory management that has resulted in the establishment of more than 14,000 community forestry user groups. It will also build the framework of "Citizen Rangers" or Bagh Heralu (tiger watchers) developed to monitor livestock depredation across the Nepalese Terai (Gurung et al., 2006). Strong involvement of local people who work as partners with wildlife staff to address the issue of human-killers is based on the belief that villagers have local knowledge that can contribute to reducing human–tiger conflicts.

5.2. *Continue the long term tiger monitoring program*

In recent years, more rigorous verification and documentation of kill sites is required for the victim's family to receive compensation from the Park. The Long Term Tiger Monitoring (LTTM) Program, in close association with Park management and local people, could serve this purpose. The buffer zone management Act authorized CNP to utilize 30–50% of Park revenue toward local community development and conservation programs (Heinen and Mehta, 2000; Budhathoki, 2004). Some of these funds are used to provide compensation payments to the victim's family, if the person is killed in the buffer zone. However, compensation is not provided if the kill occurs inside the Park (because the victim would have been trespassing at the time of the kill) or beyond the buffer zone boundary. Every incident of human-killing or injury requires

investigation; if the person died, a payment of Nepalese Rupees 25,000 (approximately US $385) is provided to the victim's family. If the victim recovers, he/she receives a payment of up to Nepalese Rupees 10,000 (approximately US $153) for medical expenses. The LTTM Program will continue to produce highly skilled people to identify true human-killers. In the 1980s and 1990s, when most of the people were killed inside the Park, field biologists and technicians from the Tiger Ecology Project (now NTNC) and the LTTM project assisted Park authorities in identification and removal of human-killing tigers. Park management currently needs such assistance from the projects and local people to monitor tigers and mitigate the conflict.

5.3. *Implement tiger conservation awareness program*

The majority of people killed by tigers were fodder collectors. However, in a few cases, the victims were attempting to steal kills from a tiger to obtain the meat. A tiger conservation education program is needed to inform local people about tiger behavior. Particular attention should be given to teaching villagers about the risk of harvesting forest resources and strategies for minimizing this danger. It is also important to include information on the basic biology of tigers and other large mammals to emphasize the role of intact healthy forests in supporting both tigers and other wildlife present in the region. Recommending an education program is motivated by the assumption that local people, who understand their own resource needs, as well as those of the tiger, will be able to apply local knowledge to efforts to reduce human–tiger conflicts.

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