

Numbers of human fatalities, injuries, and illnesses in the United States due to wildlife

MICHAEL R. CONOVER, Jack H. Berryman Institute and Department of Wildland Resources, Utah State University, Logan, UT 84322-5210, USA mike.conover@usu.edu

Abstract: I reviewed published and unpublished papers, government reports, and websites to estimate how many people are injured or killed each year by wildlife or stricken by a zoonotic disease. Over 47,000 people annually in the United States sought medical attention after being attacked or bitten by wildlife, and approximately 8 people died annually. Most bites were by snakes, birds, rodents, and raccoons (*Procyon lotor*). Each year, wildlife–vehicle collisions resulted in >59,000 human injuries and >440 human fatalities, while wildlife–aircraft collisions added 16 more injuries and 10 fatalities. I also found that >68,000 people each year sought medical assistance for a zoonotic disease, and 243 of these cases were fatal. When wildlife-related casualties and fatalities are summed, >174,000 people were injured or sickened and >700 were killed by wildlife annually. These figures do not mean that wildlife populations should be reduced; they do indicate, however, that wildlife biologists have an opportunity to serve society by preventing human injuries, morbidities, and fatalities resulting from wildlife. In doing so, wildlife biologists will also be protecting the future of wildlife.

Key words: aircraft collisions, bird–airplane collisions, deer–vehicle collisions, fatalities from wildlife, predator attacks on humans, wildlife–vehicle collisions, wildlife–human conflicts, zoonotic diseases

WILDLIFE CAUSES numerous human injuries and fatalities by attacking or biting people, colliding with vehicles, striking aircraft, and serving as vectors or reservoirs for zoonotic diseases. Only a small fraction of human–wildlife interactions result in human injury or death, but the loss of even 1 person is a tragedy. These incidences often attract a great deal of media coverage and can have a large impact on public perception of wildlife (Wolfe 2008).

The most recent national assessment on the number of human injuries and fatalities from wildlife was conducted 17 years ago (Conover 2002). Hence, the current magnitude of the problem in the United States is unknown. This reduces our ability to allocate effectively scarce resources to mitigate the risk to humans posed by wildlife. Consequently, the goal of this paper is to determine the current number of human fatalities, injuries, and morbidity annually in the United States due to human–wildlife interactions at the time of this study (2018).

Methods

I define wildlife as terrestrial wildlife (reptiles, birds, and mammals). Most medical records do not distinguish between free-ranging animals and captive animals. Hence, I cannot do so either. For most wildlife, this does not provide

a problem because most wildlife species are not kept as pets. But snakes are kept as pets, and snake-bite victims include people bitten by both free-ranging snakes and pets. I provide information on the proportion of injuries from free-ranging animals when it is available. I defined a zoonotic disease as a human disease for which that pathogen uses animals as either a reservoir or vector but excluded those that are primarily spread by human-to-human contact.

My goal was to determine the most accurate data on the extent of human fatalities, injuries, and morbidity in the United States from wildlife. To obtain these data, I searched for unpublished reports and those published in peer-reviewed journals containing information on the extent of human fatalities, injuries, and morbidity in the United States by using Google Scholar, Google, and websites of wildlife agencies. Once an article on the subject was located, I searched its literature cited section for data and other additional pertinent literature. Most journal websites also provide information about where their articles have been cited since publication. These articles were likewise searched to locate pertinent articles. I also searched the World Health Organization and Centers for Disease Control and Prevention (CDC) websites and publications for information. Of

special importance was the CDC's publication, *Morbidity and Mortality Weekly*. Some sources on attacks on humans by large predators did not provide separate data for just the United States, but instead reported data for North America, usually meaning the United States and Canada. I included these sources but identified the area of the study as North America rather than the United States.

My literature search usually produced several reports about the frequency or incidence of attacks by a particular species, wildlife–vehicle collisions, bird–aircraft collisions, or a zoonotic disease that differed by the year the data were collected. In these cases, I reported the results of all studies so that readers could compare them. When there were multiple sources, I needed to determine which study provided the most accurate data on current conditions for the United States. Hence, I used the most recent data and the data that covered the greatest proportion of the country. Sometimes, I was able to combine data from different studies when they covered non-overlapping parts of the United States. For example, state wildlife agencies report how many people in their state were bitten by alligators (*Alligator mississippiensis*). By combining these state reports, I was able to gain an accurate estimate of the number of people bitten by alligators within the entire United States.

Studies often differed in the method used to assess the extent of the problem. For example, data on zoonotic diseases often can be obtained from 4 sources: (1) cases submitted to the CDC for reportable diseases, (2) doctor reports to state health agencies in those states where such reports are required by law, (3) patient visits to hospital emergency rooms, and (4) queries to poison-control centers in the United States. In such cases, I used the data that represented the greatest proportion of the patient population and relied on sources in the same order they appear above (i.e., 1, 2, 3, and 4) because that is the order of the completeness of their coverage. Reportable diseases (#1 above) are those diseases and medical problems for which medical providers are required by federal law to report them to federal health agencies. Data on reportable diseases, therefore, cover most U.S. patients where a diagnosis was made. Excluded from these data are victims that

did not seek medical attention and patients whose disease was misdiagnosed. Some states require doctors to report additional diseases or medical problems (such as a bite by a wildlife species), but this varies among states. Hence, these data (#2 above) are not complete for the entire United States but represent a collection of states. It is for this reason that I used CDC data over state data in trying to determine data for the entire country. Data on patient visits to emergency rooms or calls to poison-control centers cover a large proportion of the United States but only include victims who seek their services. The problem with these 2 data sources is that it is unclear what proportion of victims utilize these services.

Results

Injuries from attacks and bites by wildlife species

Snakes. Several sources provided information on the number of people bitten by snakes in the United States. The CDC (2016) estimated that 6,000–8,000 people are bitten by a venomous snake each year, and Forrester et al. (2018) found that 6 snakebite victims die annually in the United States. The American Association of Poison Control Centers was an association of 61 poison control centers, which covered 300 million U.S. residents (Langley 2008). They received annually an average of 6,803 calls from snakebite victims and 1,050 calls from victims of other reptiles from 2001 to 2005 (Langley 2008). What proportion of snakebite victims in the United States called poison control centers was unknown, but it was possible to use the data to determine which species of snakes bit people; 2,409 people identified the snake that bit them. Of these, 1,193 people were bitten by rattlesnakes (Viperidae), 869 by copperheads (*Agkistrodon contortrix*), 173 by cottonmouths (*Agkistrodon piscivorus*), and 82 by coral snakes (Elapidae). During this same 5-year period, 27 human fatalities from snakebites were reported to poison control centers, including 3 bites from timber rattlesnakes (*Crotalus horridus*), 2 from eastern diamondback rattlesnakes (*Crotalus adamanteus*), 3 from rattlesnakes of unknown species, 4 from pit vipers of unknown species, and 15 from unknown species (Langley 2008). At the same time, an average of 9,015 people visited emergency rooms annually seeking

Table 1. Best estimate of the annual number of people injured or killed in the United States after being bitten or attacked by wildlife, involved in a wildlife–vehicle collision, wildlife–aircraft collision, or sickened by a zoonotic disease. These data only include people who sought medical attention and they had a reportable disease (i.e., one that the doctor was required by law to report to state and federal health agencies). The disease statistics include both confirmed and probable cases in humans.

Causes	No. injured or sickened	No. killed	Sources
Snakes (nonvenomous)	6,135	0	O’Neil et al. (2007)
Snakes (venomous)	7,000	6	Centers for Disease Control and Prevention (2016)
Alligators	9	1	Florida Fish and Wildlife Conservation Commission (2018), Texas Parks and Wildlife (2004)
Reptiles (excluding snakes)	1,050	?	Langley (2008)
Birds (excluding parrots)	1,594	0	O’Neil et al. (2007)
Bats	1,335	0	O’Neil et al. (2007)
Rodents	27,000	0	Conover et al. (1995)
Opossum	375	0	O’Neil et al. (2007)
Skunk	750	0	Conover et al. (1995)
Raccoons	1,310	0	O’Neil et al. (2007)
Foxes	500	0	Conover et al. (1995)
Coyotes	9	0.1	Timm et al. (2004)
Wolves	0.7	0.1	Wikipedia (2018a)
Cougars	3.3	0.3	Wikipedia (2018b), Penteriani et al. (2016)
Black bears	25	0.3	Herrero (1985)
Grizzly bears	0.8	?	Smith and Herrero (2018)
Polar bears	0.1	0	Smith and Herrero (2018)
Bison	1.7	0	Cherry et al. (2018)
Elk	3.0	0	Conover (unpublished)
All bites and attacks	47,102	7.8	
Deer–vehicle collisions	58,622	440	This paper
Moose–vehicle collisions	640	6	This paper
Bird–vehicle collisions	10	1	This paper
Wildlife–civilian aircraft collisions	16	1	Thorpe (2012)
Wildlife–military aircraft collisions	?	9	Conover et al. (1995)
All collisions	59,288	457	
Zoonotic diseases	68,509	243	
All causes	174,899	708	

treatment for snakebites, including 6,315 cases for bites by nonvenomous snakes and 2,820 by venomous snakes (O’Neil et al. 2007). I have reported 7,000 (Table 1) because it is the mean of data provided by the CDC (2016).

Alligators, other reptiles, and birds. Alligators injured 567 people and killed 24 in the United

States from 1948 to 2009 (Table 2). Most attacks occurred in Florida where alligators are abundant. Crocodiles posed a much greater problem in other countries than alligators, but there have been no crocodile attacks reported in the United States. (Langley 2010). The U.S. poison control centers received an average of

Table 2. Studies of the annual rate of nonfatal and fatal injuries to humans by wildlife in different parts of the U.S. and Canada. Excluded are injuries for which the victim did not seek medical attention.

Species	Location	Years of study	Injuries/year		Reference
			Nonfatal	Fatal	
Venomous snakes	United States	2015	7,000	5	CDC (2016)
	United States	2001–2004	2,820	0	O’Neil et al. (2007)
	United States	2008–2015	?	6	Forrester et al. (2018)
Nonvenomous snakes	United States	2001–2004	6,135	0	O’Neil et al. (2007)
American alligators	United States	1948–2009	7	0.3	Langley (2010)
	United States	1990–1995	18	0.3	Conover and DuBow (1997)
	Florida	1948–1992	3.5	0.1	GutierrezSanders (1992)
	Florida	2018	8	1	Florida Fish and Wildlife Conservation Commission (2018)
	Texas	1989–2004	1	0	Texas Parks and Wildlife (2004)
Reptiles (excluding snakes)	United States	2001–2005	1,050	?	Langley (2008)
Birds (excluding parrots)	United States	2001–2004	1,594	0	O’Neil et al. (2007)
Bats	United States	2001–2004	1,335	?	O’Neil et al. (2007)
Rodents	United States	2001–2004	15,832	?	O’Neil et al. (2007)
Mice	United States	2001–2004	4,075	?	O’Neil et al. (2007)
Rats	United States	2001–2004	5,383	?	O’Neil et al. (2007)
Squirrels	United States	2001–2004	3,126	?	O’Neil et al. (2007)
Rats	United States	2008–2015	?	0	Forrester et al. (2018)
Opossum	United States	2001–2004	375	?	O’Neil et al. (2007)
Skunks	United States	1971–1972	750	0	Conover et al. (1995)
	United States	2001–2005	261	0	Langley (2008)
Raccoons	United States	2001–2004	1,306	0	O’Neil et al. (2007)
Foxes	United States	1971–1972	500	0	Conover et al. (1995)
Wolves	North America	2000–2018	0.7	0.1	Wikipedia (2018a)
Coyotes	California	1989–1993	1.4	0.2	Timm et al. (2004)
	California	1999–2003	9.2	0.0	Timm et al. (2004)
	North America	1960–2006	3.5	0.02	White and Gehrt (2009)
	North America	2004–2015	7.2	?	Penteriani et al. (2016)
Black bears	United States	1960–1980	25	0.3	Herrero (1985)
	Alaska	2005–2015	6.7	?	Smith and Herrero (2018)
	British Columbia	1960–1997	0.4	0.2	Herrero and Higgins (1999)
	Alberta	1960–1998	0.2	0.1	Herrero and Higgins (2003)
	North America	1960–2009	?	1.2	Herrero et al. (2011)
	North America	2000–2009	?	1.7	Herrero et al. (2011)
	North America	2004–2015	1.2	?	Penteriani et al. (2016)

Continued on next page...

Continued from previous page.

Grizzly bears	North America	1900–1980	3.7	0.5	Herrero (1985)
	North America	2004–2015	2.2	?	Penteriani et al. (2016)
	British Columbia	1960–1997	1.1	0.2	Herrero and Higgins (1999)
	Alberta	1960–1998	0.6	0.2	Herrero and Higgins (2003)
	Alaska	2005–2015	0.8	?	Smith and Herrero (2018)
Polar bears	Alaska	2005–2015	0.1	?	Smith and Herrero (2018)
Cougars	United States	1890–1990	0.2	0.05	Beier (1991)
	North America	1890–2001	0.7	0.15	Linnell et al. (2002)
	North America	1991–2000	2.7	1.2	Linnell et al. (2002)
	North America	2000–2018	?	0.3	Wikipedia (2018b)
	North America	2004–2015	3.0	?	Penteriani et al. (2016)
	California	1986–1995	0.9	0.2	Mansfield and Charlton (1998)
Bison	Yellowstone National Park	1978–1992	3.7	0.1	Conrad and Balison (1994)
	Yellowstone National Park	2000–2015	1.7	0.0	Cherry et al. (2018)
Elk	Yellowstone National Park	2018	3.0	0.0	Conover (unpublished)

1,050 calls annually from 2001 to 2005 from people bitten by reptiles (Langley 2008). From 2001 to 2004, an average of 1,594 people visited U.S. emergency rooms for treatment of bird bites (excluding bites by parrots).

Rodents and small mammals. State laws required doctors in 14 states (New Hampshire, Massachusetts, New York, New Jersey, South Carolina, Georgia, Florida, Kentucky, Indiana, Illinois, North Dakota, South Dakota, Texas, and Arizona) to report to public health officials when someone had been bitten by an animal (Moore et al. 1977). Because these states were widely distributed across the country, the results could be extrapolated to the other 36 states with some degree of confidence (Conover et al. 1995). However, these data were conservative because they only included serious bites for which the victim sought medical attention; they did not include bites for which the person did not seek medical assistance. About 27,000 people annually sought medical attention for a rodent bite, 750 for a skunk bite, and 500 for a fox bite (Moore et al. 1977, Conover et al. 1995). These attacks far exceeded the number of attacks by large predators but received less media attention because bites by small mammals were seldom newsworthy. From 2008 to 2015, no

one in the United States died from a rat bite, but there were 3 fatalities from 1999 to 2007 (Forrester et al. 2012, 2018).

More recently, O'Neil et al. (2007) provided data on the annual number of people that sought treatment at U.S. emergency rooms annually for animal bites. The scientists found that 1,335 patients were bitten by a bat, 375 by an opossum (*Didelphis virginiana*), 1,310 by a raccoon (*Procyon lotor*), and 15,832 by a rodent. The rodent bites included 4,075 by a mouse, 5,383 by a rat, 3,126 by a squirrel, and 1,541 by another rodent. In total, O'Neil et al. (2007) reported fewer U.S. patients bitten by a rodent than the 27,000 estimated by Conover et al. (1995) because O'Neil et al. (2007) only reported visits to emergency rooms while Conover et al. (1995) included all doctor visits. I have used 27,000 as the reported number (Table 1) because I believe it to be the more accurate estimate.

Wolves and coyotes. Coyotes (*Canis latrans*) normally prey upon small mammals or the young of ungulates and livestock, which coyotes kill by clamping their jaws on the prey's throat and neck, preventing the victim from breathing. Occasionally, a person is killed by a coyote. Attacks on children are usually predatory, but coyote attacks on adults are not.

Coyote attacks on humans have increased over time. From 1999 to 2003, 46 children and adults were attacked by coyotes in California (Table 2); this compared to only 7 attacks from 1989 to 1993 (Timm et al. 2004). Across North America, there were 159 victims of coyote attacks from 1960 to 2006 (White and Gehrt 2009). There were 2 fatalities: a child in California and a grown woman in Canada; both were predatory attacks (NBC News 2010).

Wolves (*Canis lupus*) are much larger than coyotes and are efficient killers of large mammals, such as deer (*Odocoileus* spp.), elk (*Cervus canadensis*), and moose (*Alces alces*). Wolf populations are expanding in North America, both naturally and with the help of reintroduction efforts. There have been 2 fatal wolf attacks recently in North America. Kenton Joel was a 22-year-old engineering student and was killed during 2005 while hiking in northern Saskatchewan. The other victim was Candice Berner, a 32-year-old school teacher, who was killed during 2010 while jogging in Alaska (NBC News 2010).

Cougars. During the last century, 53 humans were attacked by cougars (*Felis concolor*), resulting in 11 human deaths (Seidensticker and Lumpkin 1992), but the frequency of cougar attacks on humans has increased in recent years. Only 3 people were injured by cougars in California from 1890 to 1985 (Mansfield and Charlton 1998), but that many have been attacked annually in the United States from 2004 to 2018, and a human death occurs on average every 3 years (Tables 1 and 2).

Bears. Black bears (*Ursus americanus*), grizzly bears (*Ursus arctos*), and polar bears (*Ursus maritimus*) all pose threats to people. About 30 people are attacked in North America annually by bears (Table 2). In Alaska, bear attacks averaged 7.6/year during the last decade with 88% of these involving grizzly bears, black bears 11%, and polar bears 1% (Smith and Herrero 2018).

Across North America, black bears injure more humans than any other bear species. Black bears have killed 54 people between 1960 and 2009 with most occurring in Canada and Alaska. Polar bears have attacked 6 people in the United States and 38 in Canada from 1870 to 2014 (0.3 attacks per year). Polar bear attacks have become more common in recent decades;

there was 1 attack per year from 1960 to 2009 and 3 attacks per year from 2010 through 2014, perhaps due to a reduction of sea ice from global warming (Herrero and Higgins 1999, 2003; Wilder et al. 2017). Most (59%) polar bear attacks on humans were predatory in nature; 61% of attacking bears were in poor health. Predatory attacks were more likely to result in a human fatality. Most grizzly bear attacks that result in serious human injuries or fatalities are defensive in nature and involve a female with young. Most fatal black bear attacks (88%) were predatory in nature and involved a single bear (usually male); most victims were alone when attacked (Herrero 1985, Wilder et al. 2017).

Large herbivores. There is a paucity of information about how frequently people in the United States are injured by free-ranging herbivores. One exception is Hubbard and Nielsen (2009); they reported that people at Southern Illinois University were attacked by female white-tailed deer (*Odocoileus virginianus*) that were defending their fawns hiding nearby. Moose also attack people when they feel threatened. During the 1990s, 2 people were killed by moose in Anchorage, Alaska; a man was stomped to death on the University of Alaska campus, and a woman was trampled to death in her yard (Conover 2002).

American bison (*Bison bison*) injure more people than any other wildlife species in Yellowstone National Park (Olliff and Caslick 2003). Bison injured 56 people and killed 2 people in Yellowstone National Park from 1978 to 1992 and injured 25 people from 2000 to 2015 (Table 2). Victims were an average of 3.4 m (range 0.3 to 6.1 m) away from the bison when attacked, despite park regulations requiring people not to approach within 23 m of a bison. Eighty percent of victims were approaching the bison when attacked and half were trying to take a photograph. Of the 25 injured people, 10 people were thrown into the air, 9 were head-butted, and 6 were gored; almost half (48%) required hospitalization (Cherry et al. 2018).

Human injuries and fatalities from wildlife–vehicle collisions

Each year, thousands of people are injured when their vehicle collides with a wild animal. State Farm Insurance Company (2018) reported 1,332,322 claims were filed annually with

Table 3. Annual number of deer–vehicle collisions in each state that were reported to insurance companies from July 1, 2015 through June 30, 2016 and the percent of all drivers that filed an accident claim with their insurance company stating that they had collided with a deer during the same 1-year period (based on data from State Farm Insurance Company [2018]).

State	Number of collisions	Probability of a collision (%)
Alabama	28,794	0.74
Alaska	1,135	0.21
Arizona	4,155	0.01
Arkansas	22,100	1.04
California	23,316	0.09
Colorado	14,782	0.38
Connecticut	8,118	0.32
Delaware	4,948	0.68
District of Columbia	609	0.15
Florida	15,390	0.11
Georgia	52,819	0.79
Hawaii	48	0.01
Idaho	7,668	0.68
Illinois	43,634	0.52
Indiana	32,779	0.74
Iowa	32,559	1.47
Kansas	16,181	0.80
Kentucky	29,156	0.80
Louisiana	11,031	0.33
Maine	7,357	0.72
Maryland	29,716	0.72
Massachusetts	7,500	0.15
Michigan	87,702	1.18
Minnesota	42,207	1.25
Mississippi	22,733	1.15
Missouri	36,770	0.85
Montana	13,316	1.72
Nebraska	10,509	0.76
Nevada	1,765	0.10
New Hampshire	4,590	0.43
New Jersey	24,617	0.40
New Mexico	3,042	0.21

Continued...

New York	70,405	0.62
North Carolina	61,047	0.87
North Dakota	5,773	1.10
Ohio	62,874	0.79
Oklahoma	12,605	0.51
Oregon	11,661	0.42
Pennsylvania	133,817	1.49
Rhode Island	2,167	0.29
South Carolina	39,052	1.07
South Dakota	8,765	1.43
Tennessee	31,408	0.68
Texas	54,408	0.34
Utah	9,511	0.67
Vermont	3,114	0.57
Virginia	61,141	1.06
Washington	17,612	0.33
West Virginia	28,354	2.44
Wisconsin	54,597	1.30
Wyoming	5,012	1.18
U.S. total	1,309,288	0.61

insurance companies for accidents involving deer–vehicle collisions (DVCs) during a 12-month period stretching from June 2017 to July 2018. Given the 212 million drivers in the United States, each driver has a 0.6% chance each year of filing a claim with an insurance company because of damage from a DVC. Only about half of all DVCs are reported to insurance companies or to the police (Decker et al. 1990, Marcoux and Riley 2010); hence, the actual number of DVCs occurring annually in the United States could be closer to 2.6 million annually, and the actual risk of a driver being involved in a DVC could be approximately 1.2% each year.

Annual numbers of DVCs reported to insurance companies vary by state (Table 3) with the most occurring in states with both large populations of deer and people. The most occurred in Pennsylvania (133,817), Michigan (87,702), and New York (70,405), while the

fewest collisions were in Hawaii, District of Columbia, and Alaska. The probability of a driver having a DVC was highest in states with high deer densities and a high proportion of the state's population living in rural areas (Table 3). Such states included West Virginia (2.4% of drivers annually), Montana (1.7%), Pennsylvania (1.5%), Iowa (1.5%), South Dakota (1.4%), and Wisconsin (1.3%).

Conover et al. (1995) estimated that 29,000 people in the United States were injured yearly in a DVC, and 200 people lost their lives. More recently, U.S. Centers for Disease Control and Prevention (2004) and Conn et al. (2004) reported that each year 26,726 people visited an emergency medical facility for injuries from a DVC, based on data from 2001 and 2002. Given the 1,332,322 reported DVCs, 2.0% of DVCs result in a person injured serious enough to visit an emergency medical room. Based on state highway safety data, 60,000 reported DVCs in Michigan resulted in 1,880 injuries (3.1% of DVCs) and 7 fatalities (Marcoux and Riley 2010). In Alabama, 8% of 27,780 DVCs resulted in a human injury (Hussain et al. 2007). Bissonette et al. (2008) reviewed databases for 20,873 people involved in DVCs in Utah; 2.1% visited a hospital and 0.2% were hospitalized overnight. The average of these injury rates for 3 states (3.1%, 8%, and 2.1%) is 4.4%. When 4.4% is multiplied by the 1,332,322 number of reported accidents, the results indicate that 58,622 people are injured in DVCs annually: double the rate reported by the CDC. I believe that this value is probably a more realistic record of total injuries because many victims do not visit emergency medical facilities.

In Michigan, 0.01% of DVCs resulted in a fatality (Marcoux and Riley 2010), as did 0.01% of DVCs in Alabama (Hussain et al. 2007) and 0.04% in Utah (Bissonette et al. 2008). The average of these 3 fatality rates is 0.033%; this average rate multiplied with the annual number of collisions (1,332,322) indicates there are 440 human fatalities each year from DVCs (Table 1).

Moose are much larger than deer, weighing up to 725 kg and standing 2.3 m at the shoulder—tall enough so that during a moose-car collision, the car's hood strikes a moose's legs while the moose's body and head crash into the windshield. Hence, moose collisions

are more likely than a deer collision to result in a human fatality (Pelletier 2006). There are an unknown number of collisions with moose in the United States, but Pelletier (2006) found that there were about 3,400 moose collisions in Maine during a 5-year period (2000–2004). These collisions resulted in 1,600 injuries and 17 fatalities or 320 injuries and 3 fatalities annually. Moose occur in many states bordering Canada and in the Rocky Mountains. Information on moose-vehicle collisions in these states is lacking, but I assume that their frequency in these states combined at least equals the number occurring in Maine. Hence, I estimate in the entire country, moose-vehicle collisions are at least 640 human injuries and 6 fatalities annually.

Each year, there are between 89 million and 340 million bird-vehicle collisions in the United States (Loss et al. 2014). These collisions may result in a broken windshield or dented fender, but some drivers may have swerved to the point where the vehicle collides with something else much larger than a bird. These secondary collisions undoubtedly result in a few, but unknown number of human injuries and fatalities. I think it is safe to assume that the millions of bird-vehicle collisions annually result in at least 10 human injuries and 1 human fatality (Table 1).

Fatalities and injuries from wildlife-aircraft collisions

From 1990 to 2015, there were 616 bird strikes with civilian aircraft in the United States that resulted in damage to the aircraft, 229 strikes that injured 400 people, and 12 strikes that killed 26 people. Large birds were responsible for most of the human injuries for which the animal could be identified; these included 117 injuries with Canada geese (*Branta canadensis*), 42 with vultures (Cathartidae), 31 with ducks (Anatidae), and 22 with gulls (Laridae; Dolbeer et al. 2014, 2016).

The U.S. Air Force reported an average of 3,200 bird-aircraft collisions yearly (Conover et al. 1995). From 1987 to 1993, 7 deaths were attributed to bird strikes with U.S. Air Force planes, but in 1995, 24 people lost their lives when a single AWAC aircraft collided with a flock of Canada geese in Alaska. These data amount to an average of 3.1 fatalities/

Table 4. Number of human cases and fatalities during 2015 among U.S. residents from zoonotic diseases that are reportable diseases: those that doctors are required by law to report to the health authorities. Human cases include both confirmed and probable cases. In some cases, U.S. residents acquired the pathogens while traveling abroad. An unknown proportion of these zoonotic disease cases are related to wildlife. Some zoonotic diseases, such as hantavirus, are not included because they are not reportable diseases. Most data are from CDC (2016), but fatality data for arboviral diseases came from Adams et al. (2016, 2017). Statistics for West Nile virus and other arboviral diseases are reported for 2017 (Curren et al. 2018).

Diseases	Human cases	Fatalities
Anthrax	0	0
Arboviral diseases	3,181	152
Chikungunya virus disease	896	?
Eastern equine encephalitis virus disease	5	2
Jamestown Canyon virus disease	75	2
La Crosse virus disease	63	0
Powassan virus disease	34	2
St. Louis virus disease	11	0
West Nile virus disease	2,097	146
Babesiosis	2,100	7
Ehrlichiosis/Anaplasmosis	5,137	13
<i>Anaplasma phagocytophilum</i> infection	3,656	?
<i>Ehrlichia chaffeensis</i> infection	1,288	?
<i>Ehrlichia ewingii</i> infection	14	?
Undetermined ehrlichiosis/anaplasmosis	179	?
Giardiasis	14,485	1
Hantavirus infection, non-Hantavirus pulmonary syndrome	3	?
Hantavirus pulmonary syndrome	21	5
Lassa viral hemorrhagic fever	1	?
Leptospirosis	40	?
Listeriosis	768	36
Lyme disease	38,069	15
Plague	16	0
Psittacosis	4	0
Q fever, total	156	3
Acute	122	?
Chronic	34	?
Rabies (human cases)	2	2
Spotted fever rickettsiosis	4,198	8
Tularemia	314	1
Trichinellosis	14	0
Total	68,509	243

year from 1987 to 1997. U.S. Navy officials estimate that the number and cost of bird–aircraft collisions for the Navy are similar to those for the Air Force, because the Navy flies along the coast where bird strikes are more likely. The U.S. Army has more aircraft than the U.S. Air Force, but data for collisions with Army aircraft are lacking. Using U.S. Air Force fatality rates for all branches of the armed forces yields an estimate of approximately 9 deaths/year due to bird strikes (Table 1).

Morbidity and mortality from zoonotic diseases

A zoonotic disease is one that infects both humans and animals; these diseases are much more common than most people realize (58% of all human diseases are also zoonotic). Some zoonotic diseases are reportable disease, which means that doctors, emergency rooms, and hospitals must report cases to state and federal health agencies. The CDC keeps track of how many people (human cases) have sought medical attention for reportable zoonotic diseases. The last annual record was 2015 (CDC 2016). Based on these CDC data, Adams et al. (2016, 2017) and (Curren et al. 2018) reported that 69,661 people sought medical attention for a zoonotic disease, and 376 people died (including both confirmed and probable diseases; Tables 1 and 4). These numbers are conservative because many sick people do not seek medical attention, especially if their symptoms are mild. I also have not included zoonotic diseases that are primarily spread from

one person to another, although a wild animal could have been the original source of the epidemic (e.g., avian flu, dengue). Also excluded from my study are zoonotic diseases that are not reportable, such as histoplasmosis. There are little data on the frequency of non-reportable diseases, but a half million people in the United States are believed to be infected by the histoplasmosis pathogen (*Histoplasma capsulatum*) annually, with most being asymptomatic or only having cold-like symptoms (Conover and Vail 2014).

Cumulative effects

I found that each year, >47,000 people in the United States sought medical attention after being attacked or bitten by wildlife. Most attacks were by snakes, birds, rodents, and raccoons. About 8 people lost their lives annually from these events, with most fatalities resulting from snakebites. In comparison, attacks on humans by large predators were rare. Injuries from wildlife–vehicle collisions resulted in >59,000 human injuries and >440 human fatalities, while wildlife–aircraft collisions added 16 more human injuries and 10 more deaths. I found that >68,000 people each year sought medical assistance for a zoonotic disease, and 243 of these cases were fatal. When these are added to injuries and fatalities from bites, attacks, and wildlife collisions, >174,000 people were injured and >700 were killed by wildlife annually. These figures are conservative because they do not include people who did not seek medical attention or were stricken with a zoonotic disease that was also contagious (e.g., salmonella) or by a disease that the CDC failed to track.

Discussion

I found that attacks by alligators, cougars, polar bears, grizzly bears, black bears, and coyotes have been increasing in recent decades in North America. Although these predators are diverse and live in different parts of the continent, the same factors are responsible for their recent increase in their attacks on humans. All of the predator populations have been rebounding since the early part of the twentieth century when humans poisoned and shot large predators. These animals, which currently enjoy either complete or partial legal protection, certainly have less reason to

fear humans than they did previously. Fear of humans have deterred predator attacks in the past but less so today.

Some human-habituated predators moved into urban areas, where they often interact with humans. Concomitantly, human populations have increased, and people are spending more time in remote areas frequented by these large animals. The result is that there is much more contact between these animals and humans, and occasionally these contacts have tragic consequences (Conover 2008). For instance, a tourist who visits the backcountry is 38 and 84 times more likely to be injured by a bear than a normal tourist in Yellowstone National Park and Glacier National Park, respectively (Herrero and Fleck 1989). Today, many people no longer have a healthy fear of dangerous animals and engage in activities that put them in harm's way. This naivety also contributes to the increased frequency of people being injured by wildlife. For example, people approach within a few meters of a bison in Yellowstone National Park, feed alligators in their backyards, and pick up venomous snakes so they can get a closer look.

Natural resource agencies spend time and money promoting visitation and making sure that citizens have a positive opinion of the agencies and the wildlife they manage. People are less likely to visit places where they think they are at risk; fearful people also may develop an adverse opinion of predators and wildlife. Any wildlife attack on a person will attract much attention in the news media, and stories in the media are often designed to elicit empathy for the victim (Stafford et al. 2018). Hence, a single wildlife attack on a person can undo all that was gained by a well-funded publicity campaign by a natural resource agency. Our natural resources, parks, and wilderness areas are dependent upon public support for their existence. That support wanes when people become fearful of wildlife.

Management implications

The number of human injuries, illnesses, and deaths do not mean that wildlife populations are too high or should be reduced because the benefits of wildlife far outweigh the problems they cause (Conover 2011). These incidents provide wildlife biologists an opportunity

to save lives and reduce human suffering. Biologists can teach dangerous animals to fear humans and educate humans to recognize and avoid dangerous situations involving wildlife. Methods to reduce DVCs include modifying the habitat along the roadway to make it less attractive to deer, developing methods that allow deer to cross the road safely, and/or erecting deer-proof fences to keep deer off roads. Motorists can learn that deer rarely travel alone, and that it is deer that they do not see that will likely collide with their vehicle. People can take steps to protect themselves from zoonotic diseases.

One example of progress in reducing human injuries and fatalities from wildlife interactions is the reduction in the number of bird–aircraft collisions over the last decade because of a program implemented jointly by the U.S. Federal Aviation Agency and U.S. Wildlife Services. Wildlife biologists are now stationed at all commercial airports in the United States so that the biologists and airport employees can manage airports to keep away birds and other wildlife. We need many other similar programs to address other problems caused by wildlife.

Acknowledgments

S. N. Frey, HWI associate editor, and 2 anonymous reviewers provided feedback on earlier drafts of this manuscript.

Literature cited

- Adams, D. A., K. R. Thomas, R. A. Jajosky, L. Foster, P. Sharp, D. H. Onweh, A. W. Schley, and W. J. Anderson. 2016. Summary of notifiable infectious diseases and conditions—United States, 2014. *Morbidity and Mortality Weekly Report* 63:1–152.
- Adams, D. A., K. R. Thomas, R. A. Jajosky, L. Foster, G. Baroi, P. Sharp, D. H. Onweh, A. W. Schley, and W. J. Anderson. 2017. Summary of notifiable infectious diseases and conditions — United States, 2015. *Morbidity and Mortality Weekly Report* 64:1–143.
- Beier, P. 1991. Cougar attacks on humans in the United States and Canada. *Wildlife Society Bulletin* 19:403–412.
- Bissonette, J. A., C. Kassar, and L. G. Cook. 2008. An assessment of cost associated with deer–vehicle collision, human death and injury, vehicle damage, and deer loss. *Human–Wildlife Interactions* 2:17–27.
- Centers for Disease Control and Prevention (CDC). 2004. Synopsis for August 6, 2004. Nonfatal motor-vehicle animal crash—related injuries—United States, 2001–2002. *Morbidity and Mortality Weekly Report* 53:675–678.
- Centers for Disease Control and Prevention (CDC). 2016. Venomous snakes. Centers for Disease Control and Prevention, Atlanta, Georgia, USA, <<https://www.cdc.gov/niosh/topics/snakes/>>. Accessed June 1, 2018.
- Cherry, C., K. M. Kirsten, M. Leong, R. Wallen, and D. Buttke. 2018. Risk-enhancing behaviors associated with human injuries from bison encounters at Yellowstone National Park, 2000–2015. *One Health* 6:1–6.
- Conn, J. M., J. L. Annest, and A. Dellinger. 2004. Nonfatal motor-vehicle animal crash—related injuries—United States, 2001–2002. *Morbidity and Mortality Weekly Report* 53:675–678.
- Conover, M. R. 2002. Resolving human–wildlife conflicts. Lewis Publishers, Boca Raton, Florida, USA.
- Conover, M. R. 2008. Why are so many people attacked by predators? *Human–Wildlife Interactions* 2:139–140.
- Conover, M. R. 2011. Impacts of deer on society. Pages 399–408 in D. G. Hewitt, editor. *Biology and management of white-tailed deer*. CRC Press, Boca Raton, Florida, USA.
- Conover, M. R., and T. J. DuBow. 1997. Alligator attacks on humans in the United States. *Herpetological Review* 28:120–124.
- Conover, M. R., W. C. Pitt, K. K. Kessler, T. J. DuBow, and W. A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. *Wildlife Society Bulletin* 23:407–414.
- Conover, M. R., and R. M. Vail. 2014. *Human diseases from wildlife*. CRC Press, Boca Raton, Florida, USA.
- Conrad, L., and J. Balison. 1994. Bison goring injuries: penetrating and blunt trauma. *Journal of Wilderness Medicine* 5:371–381.
- Curren E. J., J. Lehman, Kolsin, W. L. Walker, S. W. Martin, J. E. Staples, S. L. Hills, C. V. Gould, I. B. Rabe, M. Fischer, and N. P. Lindsey. 2018. West Nile virus and other nationally notifiable arboviral diseases—United States, 2017. *Morbidity and Mortality Weekly Report* 67:1137–1142.
- Decker, D. J., K. M. LocontiLee, and N. A. Connelly. 1990. Incidence and costs of deerre-

- lated vehicular accidents in Tompkins County, New York. Human Dimensions Research Group 89–7. Cornell University, Ithaca, New York, USA.
- Dolbeer, R. A., J. R. Weller, A. L. Anderson, and M. J. Begier. 2016. Wildlife strikes to civil aircraft in the United States 1990–2015. U.S. Department of Transportation, Federal Aviation Administration, Office of Airport Safety and Standards, Serial Report 22, Washington, D.C., USA.
- Dolbeer, R. A., S. E. Wright, J. Weller, and M. J. Begier. 2014. Wildlife strikes to civil aircraft in the United States 1990–2013. U.S. Department of Transportation, Federal Aviation Administration, Office of Airport Safety and Standards, Serial Report 20, Washington, D.C., USA.
- Florida Fish and Wildlife Conservation Commission. 2018. Alligator bites on people in Florida. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA, <<https://myfwc.com/media/1716/alligator-gatorbites.pdf>>. Accessed January 9, 2019.
- Forrester, J. A., C. P. Holstege, and J. D. Forrester. 2012. Fatalities from venomous and nonvenomous animals in the United States (1999–2007). *Wilderness and Environmental Medicine* 23:146–152.
- Forrester, J. A., T. G. Weiser, and J. D. Forrester. 2018. An update on fatalities due to venomous and nonvenomous animals in the United States (2008–2015). *Wilderness and Environmental Medicine* 29:36–44.
- Gutierrez-Sanders, C. 1992. Alligator attack statistics. Florida Game and Fresh Water Fish Commission, Office of Information Services, Tallahassee, Florida, USA.
- Herrero, S. 1985. Bear attacks. Nick Lyons, New York, New York, USA.
- Herrero, S., and S. Fleck. 1989. Injury to people inflicted by black, grizzly or polar bears: recent trends and new insights. *International Conference on Bear Research and Management* 8:25–32.
- Herrero, S., and A. Higgins. 1999. Human injuries inflicted by bears in British Columbia: 1960–97. *Ursus* 11:209–218.
- Herrero, S., and A. Higgins. 2003. Human injuries inflicted by bears in Alberta: 1960–98. *Ursus* 14:44–54.
- Herrero, S., A. Higgins, J. E. Cardoza, L. I. Hajduk, and T. S. Smith. 2011. Fatal attacks by American black bear on people: 1900–2009. *Journal of Wildlife Management* 75:596–603.
- Hubbard, R. D., and C. K. Nielsen. 2009. White-tailed deer attacking humans during the fawning season: a unique human–wildlife conflict on a university campus. *Human–Wildlife Interactions* 3:129–135.
- Hussain, A., J. B. Armstrong, D. B. Brown, and J. Hogland. 2007. Land-use pattern, urbanization, and deer–vehicle collisions in Alabama. *Human–Wildlife Interactions* 1:89–96.
- Langley, R. L. 2008. Animal bites and stings reported by United States poison control centers. *Wilderness and Environmental Medicine* 19:7–14.
- Langley, R. L. 2010. Adverse encounters with alligators in the United States: an update. *Wilderness and Environmental Medicine* 21:156–163.
- Linnell, J. D., R. Andersen, Z. Andersone, L. Balciuskas, J. C. Blanco, L. Boitani, S. Brainerd, Urs Breitenmoser, I. Kojola, O. Liberg, J. Loe, H. Okarma, H. C. Pedersen, H. Sand, E. Solberg, H. Valdmann, and P. Wabakken. 2002. The fear of wolves: a review of wolf attacks on humans. *Norsk Institutt for Naturforskning Oppdragsmelding* 731:1–65.
- Loss, S. R., T. Will, and P. P. Marra. 2014. Estimation of bird–vehicle collision mortality on U.S. roads. *Journal of Wildlife Management* 78:763–771.
- Mansfield, T. M., and K. G. Charlton. 1998. Trends in mountain lion depredation and public safety incidents in California. *Proceedings of the Vertebrate Pest Conference* 18:118–121.
- Marcoux, A., and S. J. Riley. 2010. Driver knowledge, beliefs, and attitudes about deer–vehicle collisions in southern Michigan. *Human–Wildlife Interactions* 4:47–55.
- Moore, R. M., Jr., R. B. Zehmer, J. I. Moulthrop, and R. L. Packer. 1977. Surveillance of animal-bite cases in the United States, 1971–1972. *Archives of Environment Health* 32:267–270.
- NBC News. 2010. Fatal wolf attack unnerves Alaska Village. National Broadcasting Company, New York, New York, USA, <http://www.nbcnews.com/id/35913715/ns/us_news-life/t/fatal-wolf-attack-unnerves-alaska-village/#.XBNGe-2fQYTY>. Accessed December 15, 2018.
- Oliff, T., and J. Caslick. 2003. Wildlife–human conflicts in Yellowstone, when animals and people get too close. *Yellowstone Science* 11:18–22.
- O’Neil, M. E., K. A. Mack, and J. Gilchrist. 2007. Epidemiology of non-canine bite and sting injuries

- treated in U.S. emergency departments, 2001–2004. *Public Health Reports* 122:764–775.
- Pelletier, A. 2006. Injuries from motor-vehicle collisions with moose – Maine, 2000–2004. *Morbidity and Mortality Weekly Report* 55:1272–1274.
- Penteriani V., M. D. Delgado, F. Pinchera, J. Naves, A. Fernandez-Gil, I. Kojola, S. Härkönen, H. Norberg, J. Frank, J. M. Fedriani¹, V. Sahlén, O. G. Støen, J. E. Swenson, P. Wabakken, M. Pellegrini, S. Herrero, and J. V. López-Bao. 2016. Human behaviour can trigger large carnivore attacks in developed countries. *Scientific Reports* 6:20552.
- Richardson, W. J., and T. West. 2000. Serious birdstrike accidents to military aircraft: updated list and summary. *Proceedings of the International Bird Strike Committee* 25:67–98.
- Seidensticker, J., and S. Lumpkin. 1992. Mountain lions don't stalk people? True or false. *Smithsonian* 22(11):113–122.
- Smith, T. S., and S. Herrero. 2018. Human–bear conflict in Alaska: 1880–2015. *Wildlife Society Bulletin* 42:254–263.
- Stafford, N. T., R. F. Welden, and B. L. Bruyere. 2018. Media reporting of conflict between wildlife and people spending time in nature. *Wildlife Society Bulletin* 42:246–253.
- State Farm Insurance Company. 2018. Deer crashes down. State Farm Insurance Company, Bloomberg, Indiana, USA. State Farm Insurance Company, Bloomington, Illinois, USA, <<https://newsroom.statefarm.com/state-farm-releases-2016-deer-collision-data/>>. Accessed January 15, 2019.
- Texas Parks and Wildlife. 2004. Authorities suggest ways for living with alligators. Texas Parks and Wildlife, Austin, Texas, USA, <<https://tpwd.texas.gov/newsmedia/releases/?req=20040503a>>. Accessed January 9, 2019.
- Thorpe, J. 2012. 100 years of fatalities and destroyed civil aircraft due to bird strikes. *Proceedings of the International Bird Strike Committee* 30:25–29.
- Timm, R. M., R. O. Baker, J. R. Bennett, and C. C. Coolahan. 2004. Coyote attacks: an increasing suburban problem. *Proceedings of the Vertebrate Pest Conference* 21:47–57.
- White, L. A., and S. D. Gehrt. 2009. Coyote attacks on humans in the United States and Canada. *Human Dimensions of Wildlife* 14:419–432.
- Wikipedia. 2018a. List of wolf attacks in North America. Wikimedia Foundation, San Francisco, California, USA, <https://en.wikipedia.org/wiki/List_of_wolf_attacks_in_North_America>. Accessed December 15, 2018.
- Wikipedia. 2018b. List of fatal cougar attacks in North America. Wikimedia Foundation, San Francisco, California, USA, <https://en.wikipedia.org/wiki/List_of_fatal_cougar_attacks_in_North_America#2010s>. Accessed December 20, 2018.
- Wilder, J. M., D. Vongraven, T. Atwood, B. Hansen, A. Jessen, A. Kochnev, G. York, R. Vallender, D. Hedman, and M. Gibbons. 2017. Polar bear attacks on humans: implications of a changing climate. *Wildlife Society Bulletin* 41:537–547.
- Wolfe, M. L. 2008. Avoiding the blame game in managing problem black bears. *Human–Wildlife Interactions* 2:12–14.

Associate Editor: S. Nicole Frey

MICHAEL R. CONOVER is a professor in the Department of Wildland Resources at Utah State University. He served as the founding editor of *Human–Wildlife Interactions* journal and the founding director of the Berryman Institute. He is currently the chair of the Wildlife Damage Management Working Group of The Wildlife Society.

