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Characteristics of non-fatal attacks by black bears: conterminous United States, 2000–2017

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Abstract: Attacks on humans by bears (*Ursus* spp.) have increased in recent decades, as both human and bear populations have increased. To help mitigate the risk of future attacks, it is important to understand the circumstances in past attacks. Information and analyses exist regarding fatal attacks by both American black bears (*Ursus americanus*) and brown bears (*U. arctos*) as well as non-fatal attacks by brown bears. No similarly thorough analyses on non-fatal attacks by black bears are available. Our study addressed this information gap by analyzing all (n = 210) agency-confirmed, non-fatal attacks by black bears in the 48 conterminous United States during 2000 to 2017. Most attacks were defensive (52%), while 15% were predatory and 33% were food-motivated. Of defensive attacks, 85% were by female bears, and 91% of those females had young. Of predatory attacks, 95% were by male bears, and of food-motivated attacks, 80% were by male bears. Forty percent of defensive attacks by female bears involved dogs (*Canis lupus familiaris*). Sixty-four percent had an attractant present during the attack and 74% indicated there were reports of property damage by bears or of bears getting a food-reward in the area prior to the attack. A classification and regression tree model show the highest proportion of severe attacks were among a female victim who was with a dog and who fought back during an attack. When compared with previous studies of fatal attacks by black bears, which are typically predatory attacks by male bears, our results illustrate clear differences between fatal and non-fatal attacks. Our study also lends evidence to the hypothesis that dogs can trigger defensive attacks by black bears. These results have implications for risk assessment, attack mitigation, and how we advise the public to respond to an attacking bear.

Key words: bear attacks, black bear, human–bear conflict, risk assessment, *Ursus americanus*, wildlife attacks

The North American bear species, the American black bear (*Ursus americanus*), the brown (grizzly) bear (*U. arctos*), and the polar bear (*U. maritimus*), are all species facing challenges associated with their management and relationship to people (Stenhouse et al. 1988, Spencer et al. 2007, Chamberlain et al. 2012). One of these challenges is that they have the potential to injure or kill humans (Herrero 2002, Herrero et al. 2011). These incidents are extremely rare (Eager and Pelton 1979, Herrero 2002), yet state and federal agencies in the United States are required to reasonably communicate and mitigate risks associated with bears and other wildlife (Francis vs. United States 2011). Trends in attacks, risk factors, and opportunities during an encounter where a person may successfully de-escalate the situation

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Figure 1. American black bear (*Ursus americanus*) home range in the conterminous United States (Scheick and McCown 2014).

have all been successfully identified by examining past injuries by potentially lethal wildlife (Herrero 2002, Herrero et al. 2011, Mattson et al. 2011, Baker and Timm 2017).

Detailed reports are available on fatal and non-fatal attacks by brown bears and polar bears and on fatal attacks by black bears. In North America, brown bears fatally injure 1–2 persons and non-fatally injure 3–4 persons per year (Herrero 2002, Herrero and Higgins 2003). The most common motivation for a brown bear attack is defensive (Herrero and Fleck 1990, Herrero 2002). These cases are often caused by a human getting close enough to a bear to trigger a physical response during a surprise encounter. A less frequent scenario is a predatory attack by a brown bear. In these situations, the attacking bear is often both human-habituated and food-conditioned (Herrero and Fleck 1990). There have been 73 documented polar bear attacks in the last 144 years worldwide (Wilder et al. 2017), 20 of which were fatal. Most were predatory attacks by nutritionally stressed male bears (Wilder et al. 2017). Unlike fatal attacks by brown bears, but similar to polar bear attacks, fatal attacks by black bears tend to be predatory (Herrero et al. 2011). Of the 63 known fatalities caused by black bears in North America between 1900 and 2009, 88% were classified as predatory and 92% of those attacks involved male bears (Herrero et al. 2011).

There has not been similar examination of non-fatal attacks by black bears. The most cited estimate is that black bears caused approximately 500 injuries to humans in North America between 1960 and 1980 (Herrero and Fleck 1990, Herrero 2002). Ninety percent of these were inflicted by food-conditioned bears and resulted in minor injuries. This estimate suggests that non-fatal attacks may occur under different circumstances than fatal attacks. Additional information is needed on non-fatal attacks for variables that are similar to those collected while examining past fatal attacks. The objective of our study is to fill this information gap by answering 2 specific research questions: (1) what are the conditions or factors preceding and during non-fatal attacks by black bears, and (2) what influences the severity of non-fatal attacks? We predicted that non-fatal attacks would be primarily associated with defensive reactions by females with young, which often involve a dog (*Canis lupus familiaris*) and result in minor bodily damage (Hristienko and Herrero 2014), and that severe attacks would be primarily associated with predatory attacks by male bears (Herrero and Fleck 1990, Herrero 2002, Herrero et al. 2011). In addition to these predictions, we sought to provide general descriptive statistics and narrative, qualitative descriptions for all data collected that may provide additional identification of trends and risk factors.

Study area

Our study area is the black bear range in the conterminous 48 United States, as defined in Scheick and McCown (2014), which represents the most recent analysis for species distribution

(Figure 1). Climate, competition for resources, population densities, biophysical characteristics, management regimes, and anthropogenic risks vary considerably within this area. We decided to exclude Canadian provinces and Alaska, USA, due to documented differences in relative bear and human densities as well as attack rates (Herrero et al. 2011). Both Alaska and Canada tend to have higher black bear to human densities, and a greater number of reported fatalities of humans by black bears, than our study area (Herrero et al. 2011). This has led researchers to suggests that there may be different motivations or conditions for attacks in these areas, and therefore we excluded them from our study (Herrero et al. 2011). While some of our study area may also fit the characteristics of low human density and high black bear density, they do not have similar fatality rates of those in Canada and Alaska (Herrero et al. 2011).

Methods

We began by collecting information on all incidents that involved black bears in the conterminous 48 states during 2000 to 2017. We selected the year 2000 as a starting point due to the widespread changes in management practices and populations of black bears. These included efforts throughout the study area to: (1) reduce the availability of human attractants to bears, (2) increase public education on bear encounters, and (3) address changes in policy such as anti-feeding ordinances and enforced safe viewing distances (Herrero 2002, Hristienko and McDonald 2007, Mazur 2015). In addition, populations of black bears in the eastern United States have increased in recent decades, which has been associated with an increase in conflicts (Spencer et al. 2007). Our goal by limiting data collection to post-1999 was to reduce the bias of attack characteristics that may have been altered by these changes in management strategies and black bear abundance and to maximize the accuracy and availability of information about the attacks.

We began data collection with a media search conducted with Google™ Media Archives using the search terms "black bear" AND "attack" OR "injury" OR "mauling" AND "x: |*state name*|." Following the search, we contacted a bear biologist at each state's management agency by email and/or phone to confirm the media-sourced incidents, identify additional incidents, and add information on the variables specific to each. Federal agencies were contacted when states lacked data on federal lands. Tribal agencies were not contacted because no injuries were discovered on tribal lands during the search. We only included data in our analysis from a media source if they were also confirmed by a state or federal agency. Attacks were then independently coded (i.e., classified by attack metric for each variable) by 2 investigators based on the accepted definitions (Table 1). If the investigators disagreed, the incident and the definitions were examined. In some cases, the definition was refined for clarity. If a definition was refined during the coding process, all attacks were recoded to ensure consistency with the updated definition. If an examination or refined definition did not clarify the disagreement, the variable was marked as unknown.

A bear attack is defined differently depending on the agency. Some agencies consider an attack to be anytime that physical contact is made between a bear and a human, while others only consider attacks to be unprovoked encounters resulting in injuries. To standardize the definition of attack across the study area, we combined 2 formalized definitions from Hopkins et al. (2010) and Baker and Timm (2017). We defined an attack as an intentional contact initiated by ≥1 non-captive, non-rabid bear that resulted in bodily damage to ≥1 human at a specific location and point in time. An incident was considered intentional when the bear had made purposeful contact. An example of unintentional contact is where a bear knocked over a person while attempting to flee an area. An incident was considered initiated by a bear if it made the first approach or physical contact. Examples of situations not initiated by a bear were when a person approached too close for a photograph, when a person attempted to pet a bear, when a hunter approached a wounded bear, or when a person inserted themselves between a bear and dog during a fight. We classified an incident as an attack if it satisfied this definition and only included those incidents considered an attack in our results and analyses.

Attacks were classified as severe or not severe. A severe attack was based on the sever-

Table 1. Variables, attributes, and their definitions for each non-fatal attack by American black bears (*Ursus americanus*) recorded in the conterminous United States, 2000–2017.

Variable	Attributes	Definition or citation of previous definition
Bear age	Subadult, adult	Subadult: weaned but not yet breeding. Adult: breeding individual.
Bear sex	Male, female, female with young	Sex was determined only when physically examined or when an adult was in presence of cubs.
Bear behavior	Defensive, predatory, food-motivated	Defensive attack: bear causes injury to defend itself, its food, or its young from a perceived threat. Predatory: a bear that preyed or attempted to prey on people (Herrero and Higgins 2003, Herrero et al. 2011). Food-motivated: a bear that appeared willing to injure a human to obtain or investigate food.
Victim age	Child (≤12), teenager (13–19), adult (20–66), and elderly (≥67)	
Victim sex	Male, female	
Victim activity	Camping, at home, slow sports, fast sports, hunting, conducting natural surveys, and other	Slow sports: hiking or walking. Fast sports: running or biking.
Victim response before	Dominant, submissive, sleeping, running, no time to respond, or other	Dominant: yelling, throwing things, waving arms. Submissive: backing away, freezing, climbing a tree. No time to respond when a person was unaware of bear prior to attack.
Victim response during	Fight, play dead, run, climb tree, bear spray, weapon (gun, knife, or blunt force object), or other	
Attractant	Yes/no	We considered people's food, garbage, or scented items as an attractant present at the attack within 100 m of the attack site (Herrero et al. 2011).
Prior bear activity	Yes/no	Food-reward or property damage reported or observed within the area of the attack, prior to the attack, within that active season.
Front/back country	Front or back country	Front-country: locations within 2 km of traveled roads. Back-country: locations >2 km from traveled roads (Herrero et al. 2011).
Severity of attack	Yes/no	Default to agency categorization. When absent, multi-day hospitalizations, loss of limb or sensory organ, or when long-term damage was reported by the victim, such as limited mobility or functionality of limb, considered severe. Example: a person with a scratch or bite that received stitches in an emergency room and was released the same day would not be considered severe.
Dog	Yes/no	
Time of day	Hour or day/night	

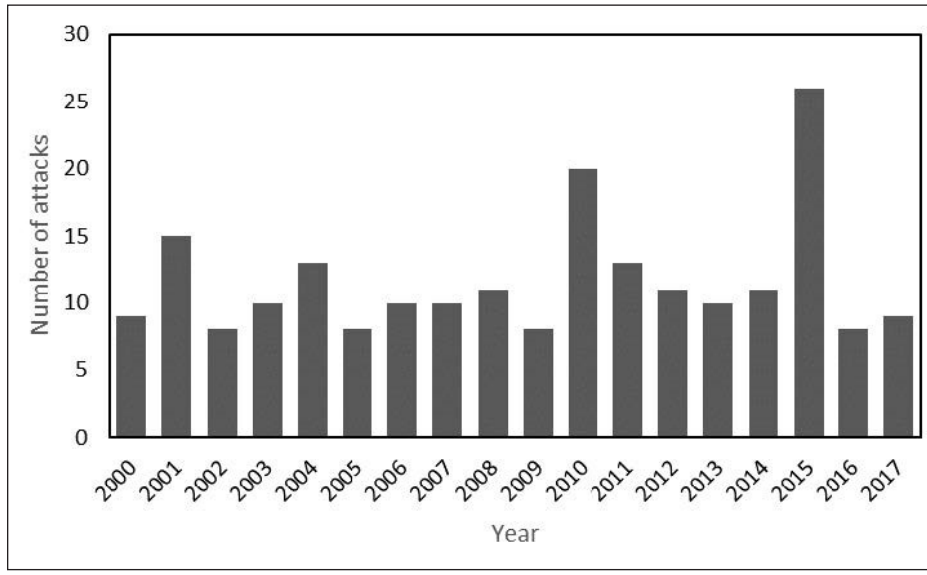

Figure 2. Annual number of non-fatal attacks by American black bears (*Ursus americanus*) in the conterminous United States, 2000–2017.

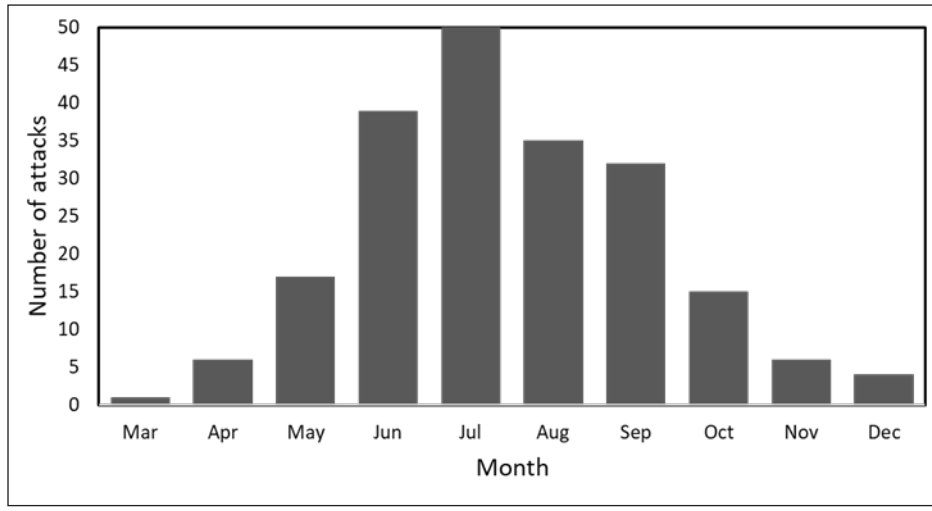

Figure 3. All non-fatal attacks by American black bears (*Ursus americanus*) in the conterminous United States, 2000–2017, by month.

ity of the bodily damage sustained by the victim. We based this on the classification reported by the agency. In the absence of a classification, we determined the victim's bodily damage was severe, thus classified as a severe attack, based on (1) multiple day hospitalization, (2) loss of limb or sensory organ (eye, ear, hand, leg), or (3) long-term damage, such as reduced use or functionality of a limb or an organ.

We evaluated 13 other independent variables associated with each non-fatal attack (Table 1). Similar to other studies, data for some of these variables were not available for all attacks. When reporting data on attack variables, we indicated the total number of attacks for which a variable was known. This created a different sample size for each variable. We reported each variable as a percentage of the known total. For example, if we knew the bear's behavior in 120 of the total 210 attacks, and the bear was defensive in 72 of those, we would report 60% (72/120) of attacks were defensive. Then, if we knew the victim's behavior in 79 of the 120 defensive attacks, and the victim behavior was submissive in 23 of

those, we would report that in 29% (23/79) of defensive attacks, the victim acted submissively.

We used specific, standardized definitions for each independent variable, many of which have been defined in previous publications (Table 1). Additional clarifications were made to other variables. For instance, we added a category to bear behavior that we termed food-motivated. Following previous studies (Herrero and Fleck 1990, Herrero and Higgins 2003), we defined attacks as predatory or defensive. While coding injuries, however, some emerged that satisfied the definition of an attack but did not meet the definition of either predatory or defensive. These attacks involved a bear that appeared to be willing to injure a human to investigate or obtain food. An example of this behavior would be a bear approaching a camper and swatting at them. After the contact, the bear then grabs a piece of food and runs away. This bear is not attempting to prey on a person, and it is not defending itself from a perceived threat.

In addition to reporting descriptive statistics, we compared data related to our severity definition using a classification and regression tree (CART) model. We chose to use a CART model as opposed to other binary modeling approaches such as logistic regression due to its classification accuracy, ability to handle potentially complex interactions among predictors, and the ability to visualize the model (De'Ath and Fabricius 2000). We calculated the number of attacks per 500,000 people and per 1,000 bears for each state (Spencer et al. 2007). Metropolitan counties where bears do not occur were removed to reduce the effect of high population centers not exposed to bears (Spencer at al. 2007). Bear populations were taken from the most recent available population estimate by each state agency. All statistical analyses were performed in program R version 3.3.1 (R Development Core Team 2016), using rpart (v4.1-15; Therneau, 2019) and rplot (v3.0.8; Milborrow, 2018) to fit the CART model.

Results

In total, we identified 291 incidents, with 210 of those satisfying our definition of attack. Our media search identified 113 injuries by black bears in the conterminous 48 states between 2000 and 2017. Agency information discredited 8 of these and provided additional information for each as well as for 186 additional incidents not identified in the media search. There was an average of 11.7 attacks per year with no discernable trend over time (Figure 2). Most attacks (n = 50) occurred in the month of July (Figure 3). Half of all attacks occurred in California, USA (n = 63) and Colorado, USA (n = 42; Table 2). Colorado and California also had the highest number of attacks per capita (Table 2). Sixty-nine percent (113/165) of attacks occurred at front-country locations. (Keep in mind the changing sample size is based on the total number of attacks for which that variable was known. In this case, of the 210 attacks in our database, 165 attacks were known if they occurred in a front or back country location.) Two attacks involved bodily damage to >1 person, and none involved multiple attacking bears. We excluded 1 attack that had the characteristics of a non-fatal attack, but the victim later died from an infection of her wounds. Five bears, all males, were implicated in 2 attacks each. Of these attacks, 3 were food-motivated, 3 were predatory, and 4 were of unknown behavior. No bears were involved with >2 attacks. In only 2 of all attacks was the bear's health listed as a contributing factor, and both were listed as emaciated. In 1 attack, a bear that had injured a person went on to fatally attack another person. However, the incident did not satisfy the definition of an attack and was not included in our study.

We classified the behavior of the bears as defensive in 52% (103/197) of attacks, as food-motivated in 33% (65/197), and as predatory in 15% (29/197). Attacking bears were adults in 83% (91/109) of attacks. Bears that attacked were adults more often in defensive attacks 91% (61/67) than food-motivated 70% (14/20) or predatory 74% (14/19) attacks. The sex of the bear was female in 57% (51/90) of attacks. Of those, 86% (44/51) were females with young. Eighty-five percent (45/53) of defensive attacks were by female bears, and 91% of those were by female bears with young. Eighty percent (12/15) of food-motivated attacks and 95% (18/19) of predatory attacks were by male bears. Twenty-five percent (41/164) of all attacks involved a dog, and of those, the dog was off leash in 79% (23/29) of attacks. Of all defensive, predatory, and food-motivated attacks, 40% (37/93), 8% (2/24), and 3% (1/38), respectively, involved a dog.

Of the victims, 71% (138/195) were male, 29% (57/195) were female, and 2 attacks involved both a male and a female. Sixty-one percent

Table 2. Actual and per capita non-fatal attacks by American black bears (*Ursus americanus*) recorded in the conterminous United States, 2000–2017 by state, per 500,000 people within the black bear range, and per 1,000 black bears within the state.

State	Attacks	Attacks per 500,000 humans	Attacks per 1,000 bears
Arizona	7	3.58	2.33
Arkansas	1	0.25	0.20
California	63	9.75	2.10
Colorado	42	13.44	3.82
Connecticut	1	0.34	1.25
Florida	7	0.90	1.75
Idaho	6	5.26	0.24
Kentucky	1	0.57	1.00
Maine	1	0.57	0.03
Maryland	1	0.64	0.50
Massachusetts	3	0.66	0.67
Michigan	2	0.13	0.12
Minnesota	9	2.04	0.67
Montana	8	5.89	0.53
Nevada	1	0.87	2.50
New Hampshire	1	0.41	0.16
New Jersey	7	0.44	1.40
New Mexico	17	9.72	3.09
New York	3	0.27	0.43
North Carolina	2	0.24	0.10
Oregon	1	0.28	0.04
Pennsylvania	3	0.14	0.15
Tennessee	2	0.43	0.29
Utah	3	1.95	0.75
Vermont	1	0.81	0.19
Virginia	2	0.19	0.12
Washington	5	0.98	0.18
West Virginia	3	0.81	0.23
Wisconsin	4	0.80	0.15
Wyoming	3	4.25	N/A*

*Population estimate unavailable by the agency.

(61/100) of victims were adults, 21% (21/100) were teenagers, 10% (10/100) were elderly, and 8% (8/100) were children. The most common activity of the victim was camping (44%, 92/208), followed by being at home (21%, 44/208), slow sports (hiking or walking; 18%, 38/208), other (5%, 11/208), hunting (5%, 10/208), fast sports (running or biking; 4%, 9/208), and conducting natural surveys (2%, 4/208; Table 1). Of those who were attacked while camping, 66% (52/78) were at front-country campsites. Seventy-three percent (48/66) of those who were attacked while camping were attacked while in a tent, 24% (16/66) while they slept on the ground with no shelter, and 3% (2/66) while in a hammock. People who were alone comprised 69% (118/171) of all attacks, 18% (30/171) were in a group of 2, and 14% (23/171) were in a group

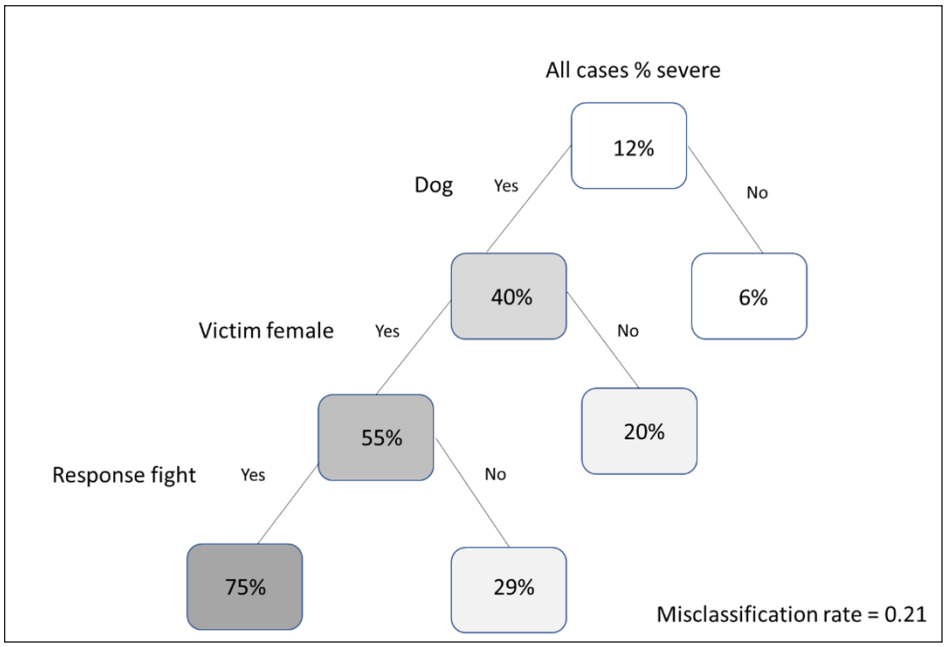

Figure 4. Classification and regression tree (CART) model predicting severity of non-fatal attacks by American black bears (*Ursus americanus*) recorded in the conterminous United States, 2000–2017.

of ≥3. For 10 of the 53 attacks that occurred on a group of ≥2 people, we were able to determine the size of the victim relative to the others in the group. Fifty percent (5/10) of those occurred on the smallest member of the group, 30% occurred on the largest member of the group, and 20% occurred on a middle size member of the group. The victim's response to the bear directly before the attack was classified as dominant in 35% of attacks (60/170), submissive in 22% (38/170), sleeping in 22% (38/170), no time to respond in 11% (18/170), run in 6% (10/170), and other in 4% (6/170). The victim's responses during the attack were classified as fight in 48% (56/118), play dead in 16% (18/118), other in 14% (16/118), run in 10% (12/118), weapon in 8% (9/118), climb tree in 3% (3/118), and bear spray in 3% (3/118).

An anthropogenic attractant was present at 64% (93/145) of attack locations during the attack, 11 of which had multiple attractants. The most common type of attractant was human food in 51% (46/90) of attacks, followed by garbage in 31% (28/90), non-food scented items in 15% (14/90), birdseed in 9% (8/90), carcass in 2% (2/90), bait intended for other species in 2% (2/90), and pet food in 1% (1/90). Seventy-four percent of attacks (54/73) had a prior food-reward or bear damage reported in the area prior to an attack. Of attacks that occurred while the victim was camping, 93% (27/29) involved a bear receiving a prior food-reward or where there was reported bear damage, and 71% (41/58) involved attractants. Attacks occurred in both day and nighttime hours with 61% (83/135) occurring at night. Sixty-three percent of defensive (37/59), 14% (4/24) of predatory, and 25% (10/40) of food-motivated attacks occurred during the day.

We classified 12% (23/188) of attacks as severe. Our CART model showed the combination of variables with the highest proportion of severe attacks were a female victim who was with a dog and fought back during an attack (Figure 4). Upon review of those results, we further disaggregated the specific predictors for comparison. Forty percent (15/38) of all attacks involving a dog were severe. Of attacks with a dog and involving a female victim, 55% (12/22) were severe. Of attacks with a dog and a female who fought back, 75% (3/4) were severe. All of the severe attacks with a dog and a female victim who fought back also involved a female bear with young. Conversely, of attacks with a dog and a male victim, 20% (3/15) were severe. Of attacks with a dog and a male who fought

back, 43% (3/7) were severe. For further clarification, 19% (17/91) of all defensive attacks, 2% (1/62) of all food-motivated attacks, and 12% (3/25) of all predatory attacks were severe. Thirty percent (13/44) of all attacks by female bears were severe and 6% (2/32) of all attacks by male bears were severe.

Discussion

Our results supported our prediction that most non-fatal attacks by black bears on humans in the conterminous 48 states between 2000 and 2017 were defensive reactions by female bears with young that often involved a dog and resulted in minor bodily damage. Our results suggest that the characteristics of non-fatal attacks were substantially different than most fatal attacks by black bears. For example, we found major differences in the proportions of bear sex by behavior (43% male and 15% predatory) in non-fatal attacks when compared to a similar study of fatal black bear attacks (93% male and 88% predatory; Herrero et al. 2011). Additionally, there was a higher proportion of non-fatal attacks (64%) in our database where an attractant contributed to the bear's presence at the attack location than previous studies of fatal attacks (38%; Herrero et al. 2011). The bears' health was categorized as a contributing factor more often in fatal attacks (32%; Herrero et al. 2011) than in our study of non-fatal attacks (<1%). We acknowledge there were differences between the proportion of sex known by behavior in our study. Of the behavior categories, sex was known in 52% (53/103) of defensive, 62% (18/29) of predatory, and 23% (15/65) of other attacks. This disproportion may bias results. In defensive attacks, sex was often determined by the visual presence of cubs. Most attacks in our study did not include information on the bears' health. This is particularly difficult for an agency to document if the bear was not euthanized after the attack, as is the case with many defensive and other attacks.

Our second prediction, that severe attacks would be primarily associated with unsuccessful predatory attacks by male bears, was not supported by our results. The combination of variables associated with the highest proportion of severe attacks was a female victim who was with a dog and who fought back during the attack. This suggests that severe non-fatal attacks are more often not the result of a failed predation attempt but are instead a defensive reaction aggravated by the presence of a dog, which are more severe on female victims, and may be more severe when those victims fight back during an attack. However, as the variables are filtered, our sample size reduces to a point where the addition of 1 or 2 attacks could change the results. Therefore, the most robust estimates are those with the largest sample size: a female with a dog.

We wish to place these results in a proper context to fully understand the situations that contribute to the risk of a non-fatal attack. Here we provide 3 common scenarios taken from our study that may not have been obvious from our quantitative results. The first was where someone was in their home and they opened their door to let a dog outside (11/41 of cases with a dog present). At the same time, a bear, usually a female with young (5/6 of cases where the bears' sex was known), was in their yard consuming or investigating an attractant. The dog would then bark at the bear and then the person would become aware of the bear and call to their dog. The bear would then target the person and attack.

The second scenario was where a person was camping and woke up to a bear biting them (32/92 of those attacked while camping were sleeping). In some attacks, the bear was attempting to drag the individual away. Nearly all of these attacks reported either a prior bear food-reward or property damage in the area (15/17 where it was known if there was an attractant or prior activity), involved male bears (11/12 where sex was known), and resulted in minor injuries (29/30 were minor where severity was known). Some of these were classified as predatory (10/33 where behavior was known [e.g., if the bear was attempting to drag a person away]). Some were classified as food-motivated (23/33) if there was an attractant present and/or there were no dragging or other predatory behaviors reported. Predation in this case appears to be an opportunistic attempt by a food-conditioned bear. The bears in these attacks, however, did not display the same persistence observed in bears whose predatory attacks resulted in fatality and consumption (Herrero et al. 2011). In most attacks, it was reported that the bear was relatively easy to scare away.

The third common scenario was when a person was walking or hiking with a dog (21/41 attacks

where it was known they had a dog present) and had a surprise encounter with a female bear (12/12 of those walking or hiking with a dog where the bears sex was known, 11/12 of which had cubs present). Many of these resulted in a severe attack (6/11 of those where severity was known). It was reported by 3 victims that they initially fought back but then changed strategies to play dead when they realized fighting back was not effective. Upon playing dead, the bear backed away. In 2 of those cases, the victim then attempted to leave the area, which triggered the bear to attack again, sometimes repeating the attack up to 5 times. Understanding these scenarios is important for developing management and education strategies that reduce personal risk.

The disproportionally high numbers of attacks in California and Colorado merit further investigation. One reason for this could be reporting bias, as, unlike most states, both documented every reported incident thoroughly. This may account for some of the disproportion but is unlikely to account for it all. The most apparent difference in California and Colorado was that they involved a higher proportion of food-motivated attacks. These involved high numbers of attacks involving attractants, male bears, and minor injuries. Many of these occurred while the victim was camping. In California, a relatively high number of attacks occurred in the 3 Sierra National Parks: Yosemite, King's Canyon, and Sequoia. These parks have much lower bear densities than the northern California region but receive higher levels of recreation and visitation by humans. These parks have seen a decrease in human–bear conflicts in recent decades because of aggressive management action aimed at reducing the availability of anthropogenic attractants (Mazur 2015). During the peak of human–bear conflict in the 1970s, dozens of injuries by black bears were reported each year in those parks (Mazur 2015).

We do not consider our database to be a complete account of all attacks within the study area and time period. Reporting biases exist. Minor injuries are potentially being reported at a lower rate. Each state has its own system for recording incidents. Some states do not keep specific records. Seven of the 32 states with attacks had databases, and these states also had the highest numbers of incidents, although it is likely that the databases were created because incidents had become more common. We did not contact managers of tribal lands and other private lands and acknowledge that cases may have been missed in these areas.

Our results also provide evidence that agencies should provide more specific recommendations for how humans respond to a bear encounter and attack. It has been long established that playing dead in a defensive encounter and fighting back during a predatory encounter are the best ways to lessen the severity of an attack (Herrero 2002). However, much of the current messaging still advises people, in generalities, to play dead with a brown bear and fight back with a black bear. This is likely because many brown bear attacks are defensive and most fatal black bear attacks are predatory. Yet our results show that more defensive non-fatal attacks by black bears occur than fatal attacks. We agree that when and if it can be determined that an attacking black bear is acting defensively, playing dead is likely more effective at stopping an attack and results in less severe injuries regardless of species.

We believe it would be useful for all agencies to keep a database of injuries to aid further investigations like this one, and that collecting standardized data will improve our ability to make inferences across management jurisdictions. Where possible, it would also be useful to track encounters that do not result in attacks for the purpose of comparing them to encounters that do result in attacks. This would give researchers the ability to assess what may influence or trigger an encounter to become an attack. There are many other factors that may be important when assessing the risk of an attack, including natural food availability, body condition, extent of wildland urban interface, the proper use of bear-resistant garbage and food storage, harvest methods and their intensity, and black bear population density (Conover 2001, Baruch-Mordo et al. 2014, Johnson et al. 2015, Miller et al. 2016, Azad et al. 2017). In most cases, these data were not available to us or were too coarse for inclusion in our analysis. We recommend data collection in these areas be improved and that further research be conducted on their influence on bear attacks.

The addition of our results to the literature on attacks by North American bear species adds to our understanding of the trends and risk factors of bear attacks. By correctly identifying situations and conditions that are associated with attacks by any wildlife with the potential

to injure or kill humans, both individuals and agencies may use this knowledge to reduce the risk of attacks. By doing so, we believe support for the continued co-habitation with these wildlife species will increase.

Management implications

Our results can be used to assist in educating people who live, work, or recreate in black bear range to avoid human behaviors that may increase the risk of an attack and that may reduce the severity of an attack. Our results suggest that making anthropogenic attractants inaccessible to bears is still one of the most important practices for minimizing human–bear conflicts, particularly non-fatal attacks by black bears on humans. Our results provide additional justification for closing recreational areas such as trails, campgrounds, and picnic areas to dogs to reduce the risk of an attack, especially if the area is being frequented by a female bear with young. Based on our results and the recommendations by previous authors and studies, we recommend agencies advise people to respond to a bear based on the bear's behavior, not species. This will require additional education that helps people identify the differences in defensive and predatory behaviors. However, if a black bear is with young, it can be reasonably assumed that the attack will be defensive.

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