

Have Black and Grizzly Bears Become More Dangerous? Insights From Human-Bear Fatality Trends

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Abstract: Since 1900, black bears (*Ursus americanus*) and grizzly-brown bears (*U. arctos*) in North America have killed nearly 150 people, and injured many more. Rising fatality rate per decade has been attributed to (a) bears becoming more dangerous, (b) more bears encountering people, and (c) more people encountering bears. Although our focus was on the first hypothesis, testing it required addressing all three. To supplement our field studies on human-bear interactions, we analyzed temporal trends in bear attacks – data obtained by literature search – updating and extending studies by Herrero, Smith and their colleagues. We demonstrated that the rise in human fatalities per decade (**F/D**) since 1900 has not been linear but sigmoidal. The rise accelerated until the mid-1960s, whereupon it seemed to stabilize briefly, before decelerating; **F/D** finally leveled off or declined in the last two decades (we prorated fatalities to the end of this decade based on numbers during January 2010- September 2019) ($R^2 = 99.7\%$, $F = 759$, $F(4,7) = 7.9$, $P < 0.00001$). We found the same pattern for fatality rate per million humans (**F/H**) (a) north of Mexico, ($R^2 = 99.7\%$, $F=502$, $P < 0.00001$). Rising human abundance statistically explains virtually all variance in rates of fatalities inflicted by black and grizzly/brown bears; however, the mechanism by which this occurs is uncertain. Although black bear abundance also rose during that period, that increase was largely in states south of Canada where there was only a single fatality. Furthermore, these results provide no support for the first hypothesis that conflict rate per encounter has been increasing – that bears have become more aggressive, whether due to lower hunting pressure or any other cause. On the contrary, fatality rate per encounter has apparently decreased. Deceleration in fatality rate began about when conflict-prevention measures were intensified following the deaths of people in Yellowstone and Glacier National Parks. This evidence that precautions have succeeded on a continental scale augments evidence of success observed at local levels (e.g., in Yellowstone National Park). That warrants increased investment in precautions; not complacency. Precautions should be continued and supplemented with more innovative methods, especially those which reduce mortality of conflict bears. Greater effort should also be invested in better understanding why food conditioning and habituation sometimes reduce risk, contrary to conventional wisdom. Agencies should foster more partnerships with non-governmental wildlife stewards who can provide extra expertise, labor, and funding.

Keywords: attack, bear, black bear, brown bear, grizzly bear, injury, fatality, risk, *Ursus*.

Especially during the last half-century, human conflict rates with black bears (*Ursus americanus*) and brown/grizzly bears (*U. arctos*) have been growing across North America, as has been documented at various geographic scales: provincial (Herrero & Higgins 1999, 2003), state (Smith & Herrero 2018) and continental (Herrero et al. 2011). Conflict growth has been speculatively attributed to bears becoming more dangerous, allegedly due to waning fear of humans, resulting from a decline in hunting pressure (e.g., Sheldon 1998, 2001). However, there remains considerable debate about the circumstances under which hunting bears decreases conflict rate or increases it (Treves 2009; Treves et al. 2010; Obbard et al. 2014; Raithel et al. 2017; Bombieri et al. 2019). Furthermore, no one has yet published statistical or observational evidence supporting conventional wisdom that un hunted bears are more aggressive than hunted ones.

Our own observational studies of human-bear interactions (to be published elsewhere) were conducted, in part, to test the hypothesis that bears become more aggressive if they are habituated, whether due to low hunting pressure or other causes. Extending that hypothesis from the behavior of individual bears to the behavior of populations logically entailed testing two other possible explanations for rising conflict rate at those geographic scales: rising abundances of bears and of humans – an approach pioneered by Steve Herrero, Tom Smith and their colleagues (Herrero & Higgins 1999, 2003; Herrero et al. 2011; Smith & Herrero 2018).

Herrero et al.'s (2011) continent-wide regression for fatalities by black bears vs. human abundance was fairly linear, suggesting that average attack rate per person had been moderately constant since 1900. However, residuals for their linear model were not randomly distributed. During four consecutive decades, residuals were negative before the next was positive, raising a possibility that the true relationship is actually curvilinear, and that conflict rate might be accelerating faster than human abundance – which would be consistent with the hypothesis that conflict (including fatality) risk per encounter has been increasing, perhaps because bears have become more aggressive. A similar trend was found for British Columbia (1960-97), although not in the aforementioned datasets from Alberta and Alaska. We therefore sought to determine whether or not black bear-inflicted fatality rate per human really tends to be constant at the continental scale, and

whether the same thing is true for grizzly bears – a dimension of the issue not previously analyzed.

Herein, we use additional data to update Herrero et al.'s (2011) analysis of fatalities inflicted by black bears, then extend it to grizzly bears for years 1900-2019. We also contrast our findings with those of Bombieri (2019) which addressed trends in attack rates throughout the global geographic range of *U. arctos* for years 2000-2015.

Methods

Ideally, the responses by attack rates to variations in human and bear abundances might be tested by assessing attack rate versus abundance of humans who encountered or were likely to encounter a bear, and against corresponding abundances of bears. However, the necessary information does not exist for the period encompassed by our analysis: 1900-2019, or across our geographic range: each Canadian Province and North American state north of Mexico (= North America, hereafter). Our analysis was thus done using what data are available: total numbers of humans in each province or state during each decade, and numbers of bears at the beginning of the 21st Century.

Sampling error

According to Herrero et al (2011), fatalities are not only the worst type of human-bear conflict, but the most thoroughly documented in bureaucratic and medical records, as well as in scientific and popular media. So, unlike previous analyses by Herrero & Higgins (1999, 2003) on both serious or fatal attacks in British Columbia and Alberta, Herrero et al (2011) restricted analysis of continent-wide black bear conflicts to fatalities in order to maximize reliability of any trends revealed. We did the same thing for black and grizzly bears.

Also like Herrero et al., we limited our analysis to attacks since 1900, in part because of suspicion that completeness of records was far lower during the 19th Century. We anticipated that incompleteness of records during at least the first half of the 20th Century would be small for grizzly and black bear inflicted fatalities, but severe for polar-bear inflicted fatalities. We suspected that if someone disappears in bear habitat, it is on the Arctic sea ice that probability was lowest of their fate being discovered and of this

knowledge finding its way into bureaucratic or scientific records, or into popular media. So our analysis excluded polar bears.

Trends

Nearly a decade has passed since Herrero et al. (2011) did their search for black-bear inflicted fatalities. To update records on fatalities by black bears, and to add fatality data on grizzly bears, we searched for fatality records using approximately the same method as Herrero et al. (2011). The cases they assessed were found by extensive searches of government documents, scientific and popular literature, and querying the worldwide web using the Google™ search engine (Google Inc., Mountain View, CA). Our own search was limited to our own records accumulated from such sources over decades and to a Google search. We also queried the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research database. Our search thus differed from that of Herrero et al. (2011) mainly in being more recent, and in extending to grizzly bears. Our search utilized various combinations of the following terms: brown bear, grizzly bear, black bear, *Ursus*, kill(ed), fatal(ity), death, injury, mauling and attack.

We also followed Herrero et al's precedent in pooling fatality data decade by decade so that fatality rate per decade could be compared to decadal census data on human abundance. Census data were obtained from Census.gov. for the United States and from CanSim Tables 075-0001 (1900-1970) and 051-0001 (1971-present). Our minimum variance regressions and ANOVA analyses were done using the `linest` and `fdist` functions in Excel 2007.

Subsequent to the Google search for 1900-2009 by Herrero et al. (2011), information on additional cases of black bear-inflicted fatalities became web-accessible – several for the period 1900-2009 and 8 cases during the current decade. Given that this is still a few months short of the active season for bears in this decade – i.e., about 5% of the decade remains, we prorated the number of fatalities: i.e., $8/95\% = 8.4$ for black bears. Data from this decade on grizzly bear inflicted fatalities were also prorated: $16/95\% = 17$ through 2019. We similarly prorated figures to 2019 for Alaska and to the end of the 1990s for British Columbia (33 for 1990-1997 prorated to 41 for 1990-1999) and Alberta (13 for 1960-1998 to 14.4 for 1990-1999).

Results

Temporal Variation in Fatalities

Grizzly vs. Black Bears: On average, the number of fatalities per decade was only slightly lower for grizzly bears than for black bears – a relationship manifest for most decades until the 1990s, despite the 14-fold greater abundance of black bears (~60,000 grizzly vs. 840,000 black bears; see Hristienko & McDonald 2007). Since the 1990s, black bear-inflicted fatalities have been especially uncommon. Nevertheless over the entire 120 year span, decadal fatality rate inflicted by grizzly bears has been positively correlated with the rate by black bears ($r^2 = 71\%$, $P < 0.001$, $n = 12$).

Fatalities per Decade: Bear-inflicted fatalities increased geometrically from 1900-2009. Data for the two species closely approximate nearly identical second-degree polynomials:

$$\begin{array}{ll} \text{Black bears:} & \text{Fatalities} = 0.0018D^2 - 6.94D + 6616 \quad R^2 = 95\%, F=84, df=8, p<0.0001 \\ \text{Brown bears:} & \text{Fatalities} = 0.0016D^2 - 5.96D + 5683 \quad R^2 = 86\%, F=22, df=8, p<0.001 \end{array}$$

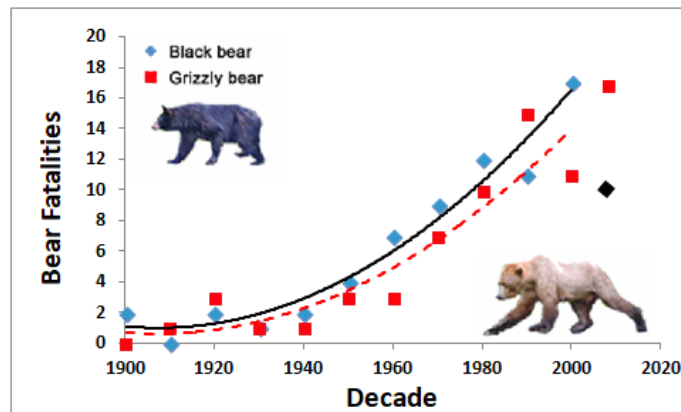


Figure 1. Fatal attacks per decade by grizzly bears (*Ursus arctos*) and black bears (*U. americanus*) in North America north of Mexico 1900-2010. There were 2 black bear attacks in 1900, one killing 1 victim, another killing 3 victims.

However, when fatalities from 1900-2009 by both species are added, data suggest that fatality rate per decade had begun declining. That was confirmed when we estimated total fatalities for 2010-2019 by prorating fatalities during January 2010-July 2019 (95% of this decade) (Figure 2). Combined fatality rate since 1900 slowly accelerated at least through the 1960's, whereupon it seemed to stabilize briefly, then decelerated, before leveling off or declining since the 2000s.

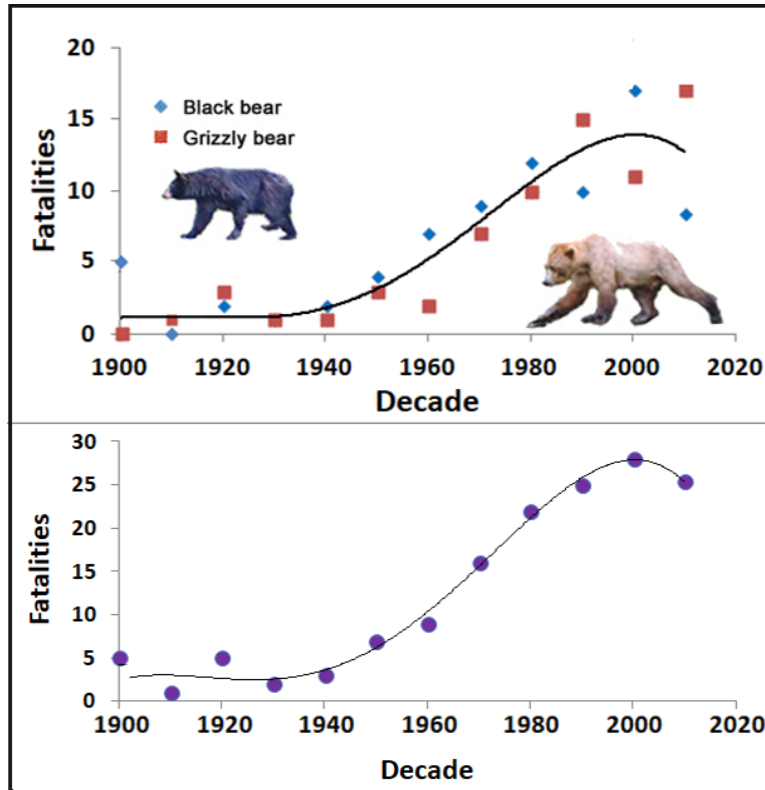


Figure 2. Fatalities inflicted by North American black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) during each decade 1900s – 2010s. (a) In the upper graph, the regression curve was fitted using pooled data for the two species. (b) In the lower graph the curve was fitted to total fatalities inflicted by the two species. Fatality rate initially increased geometrically, then straightened out, before tapering off geometrically. All data come from Canada and the United States. The 2010s datum for each species as of 30 June 2019 (95% of this decade) has been prorated to the end of this decade. The lower graph sums the fatalities for both species shown in the upper graph. The especially high black bear fatality rate for the 1900 decade was due to a unique attack in which three children were killed. No other such attack has ever been reported. So the curve was fitted by omitting that datum, to be consistent with the overall trend, as manifest in the lower graph. Nevertheless, the R^2 values given is for the entire data set, including the anomalous datum.

a) Data on both species pooled for each decade.

$$BF = -8.01E-7*D^4 + 6.30E-3*D^3 - 1.84E+1D^2 + 2.38E+4*D - 1.16E+7$$

$$R^2 = 85.7\%, F = 28, F(4,19) = 4.1, P < 0.0001$$

b) Data on both species added for each decade.

$$BF = 1.76E-6*D^4 + 1.34E-2*D^3 - 3.90E+1D^2 + 5.06E+4*D - 2.46E+7$$

$$R^2 = 98.2\%, F = 116, F(4,7) = 7.85, P < 0.00001$$

Fatalities vs. Human Abundance: Similar 4-phase trends were found for fatality rate vs. human abundance (Figure 3). (a) Fatality rate inflicted by each species initially grew slower than human abundance. (b) Fatality rate accelerated until the human population

reached ~170 million. (c) Fatality rate began decelerating as human abundance in North America exceeded ~250 million. (d) Fatality rate finally began leveling off after human abundance exceeded ~300 million.

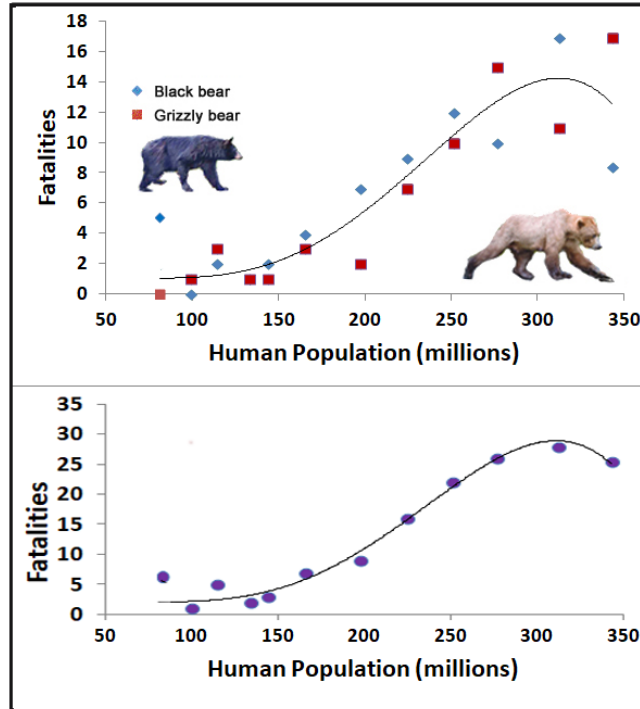


Figure 3. Human fatalities inflicted per decade by black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) relative to human population sizes in North America north of Mexico. All data come from Canada and the United States; no fatalities are known from Mexico. The 2010s datum for each species has been prorated to the end of this decade. Human population size is not the direct cause of changes in attack rate, although it might drive one or more direct causes such as the rates of human-bear encounters or habitat degradation. The black bear fatality rate for a human population of 75 million during the 1900 decade was anomalously high, as explained in Figure 2. So the curve was fitted by omitting the single attack that killed three children. Nevertheless, the R^2 values given is for the entire data set, including the anomalous datum.

a) Data on both species pooled for each decade.

$$BF = -1.41E-8P^4 + 9.01E-6P^3 - 1.67E-3P^2 + 1.26E-1P - 2.43$$

$$R^2 = 83.6\%, F = 25, F(4,19) = 4.5, P < 0.0001.$$

b) Data on both species added for each decade.

$$BF = 3.11E-8P^4 + 2.02E-5P^3 - 3.90E-3P^2 + 3.11E-1P - 7.00$$

$$R^2 = 98.8\%, F = 121, F(4,7) = 7.85, P < 0.00001$$

Geographic Variation in Fatalities

Our goal included assessing fatality rate per unit time relative to abundances and densities of bears and of humans. Although data on human abundance and density are available for each decade since 1900, even moderately reliable data on bear abundances and densities in most North American states and Canadian provinces are available only for recent decades. These were compiled by Hristienko & McDonald (2007). Hence, the only continent-wide tests we could make for relationships between fatality rate vs. bear abundance and density had to be based on Hristienko & McDonald (Figure 4a).

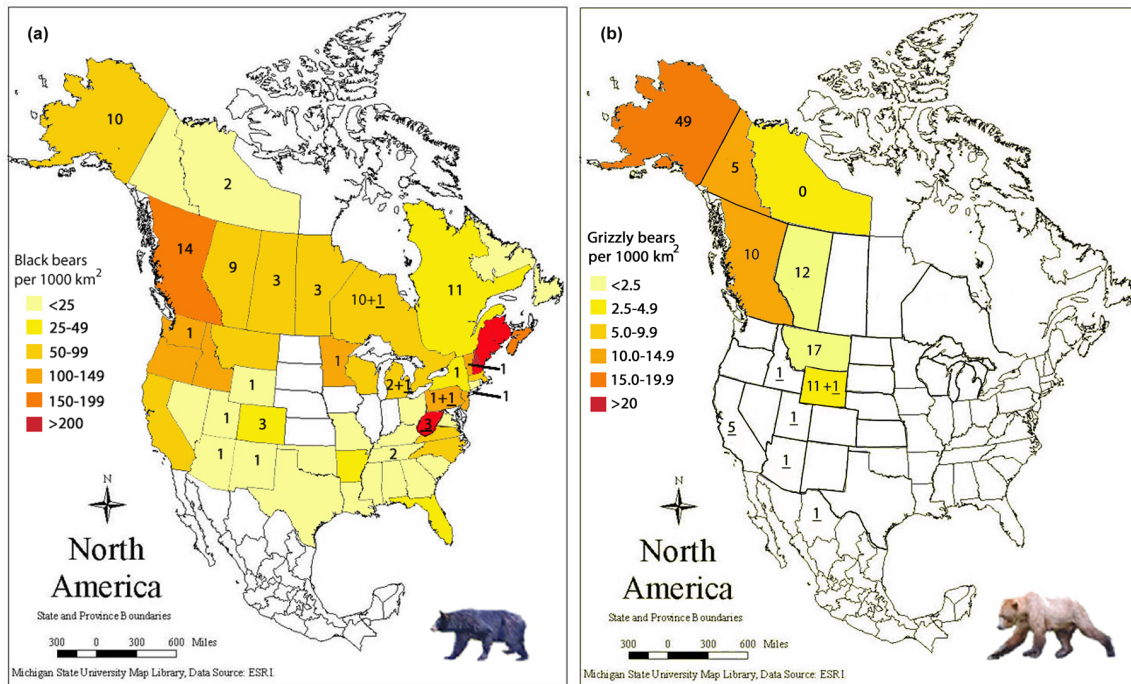


Figure 4: **Maps of black and grizzly bear-inflicted fatalities relative to bear density.** Numbers not underlined refer to fatalities during 1900-2019. Underlined numbers refer to known fatalities during 1880-1899. Black bear fatality numbers in Figure 4a updates those by Herrero et al. (2011).

Cumulative Fatalities vs. Recent Bear Abundance & Density: The historical accumulation of black bear-inflicted fatalities in each jurisdiction since 1900 was not correlated with contemporary *density* of black bears; but it was positively correlated with contemporary estimates of their *abundance*. This positive correlation ($r^2=79\%$, $n = 52$, $p<0.001$; Figure 5a) is due mainly to the high fatality rates in jurisdictions with $\geq 30,000$ bears ($r^2=66\%$, $n = 8$, $p<0.001$). Among smaller black bear populations, there is no

correlation ($r^2 = 5\%$). Indeed, in many of these jurisdictions, black bears haven't killed anyone since 1900.

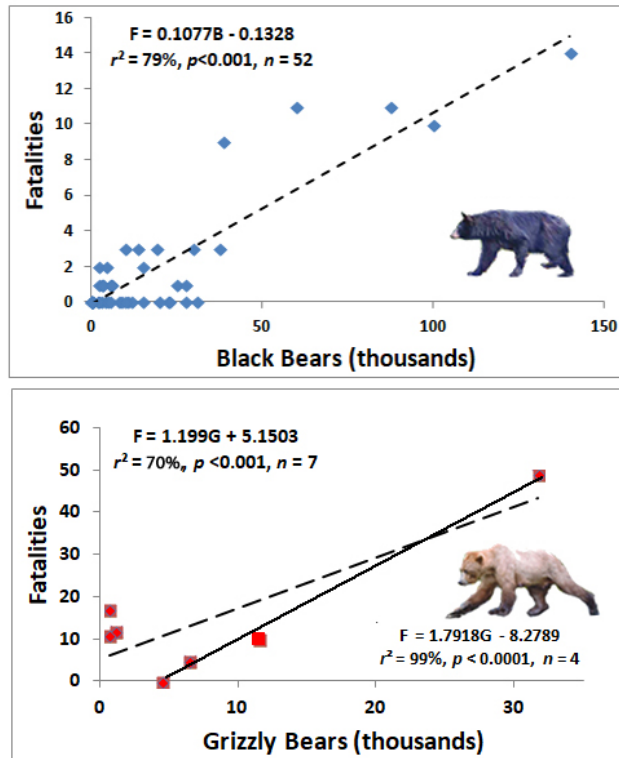


Figure 5. **Cumulative fatalities in each jurisdiction 1900-2019 inflicted by (a) black bears or (b) grizzly bears.** The dashed line in each plot represents the entire data set. The solid line in the lower graph is for the four populations which aren't concentrated in a national park.

There is also a positive correlation between cumulative fatalities vs. grizzly bear abundance ($r^2 = 70\%$, $n = 7$, $p < 0.01$, Figure 5b). This is clearest when one considers only populations not centered in a national park ($r^2 = 99\%$, $n = 4$, $p < 0.001$). Compared to that pattern, fatality rates are disproportionately high in Montana, Wyoming, and Alberta, which have only remnant grizzly populations of roughly 1000 bears concentrated in national parks.

Per Capita Fatalities vs. bear density: We also tested for a correlation between fatalities per bear vs. bear density. This cannot be done by regressing fatality rate per bear vs. bears per unit area – i.e., F/B vs. B/A , because that relationship is distorted by autocorrelation between bear abundance (B) on both sides of the equation (Stringham 1995). To find an equation for fatalities per bear vs. bear abundance which avoids

autocorrelation, we divided bear abundance into both sides of each of the above regression equations for cumulative fatalities vs. number of bears in each jurisdiction.

$$\text{Black bears:} \quad F/B = 0.108 - 0.133/B \quad r^2 = 79\%, \quad p < 0.01$$

$$\text{Non-park grizzly bears:} \quad F/B = 1.79 - 8.28/B \quad r^2 = 99\%, \quad p < 0.001$$

Using the new equation for each species, we calculated fatalities per bear vs. bear abundance. The r^2 and p -values for these equations are necessarily identical to those from regressing cumulative fatalities vs. density. Comparing among either grizzly or black bear populations with <5-10K bears, increasing population size reduced fatality rate per bear; but further increasing population size had negligible effect on fatalities per bear (Figure 6).

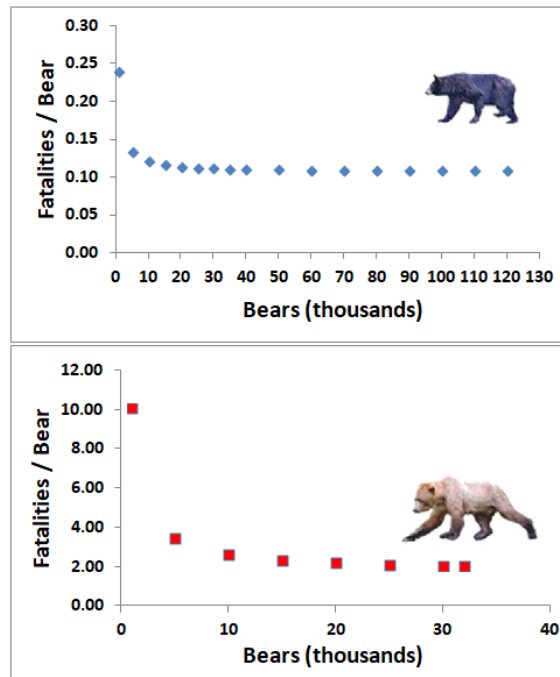


Figure 6. **Fatalities per bear relative to size of the bear population (black bears, upper graph; grizzlies lower graph) in each jurisdiction.**

For grizzly bears, there was no relationship between cumulative fatalities since 1900 vs. human abundance or density as of 2010. For black bears, there was no relationship with human abundance, but an inverse relationship with human density. Fatalities were most common in jurisdictions with no more than 2,000 humans per 100 km², but virtually non-existent in jurisdictions with more than 12,000 humans per 100 km². That is very

similar to the relationship between bear abundance vs. human density (Figure 7), which is consistent with the positive correlation between cumulative fatalities vs. bear abundance.

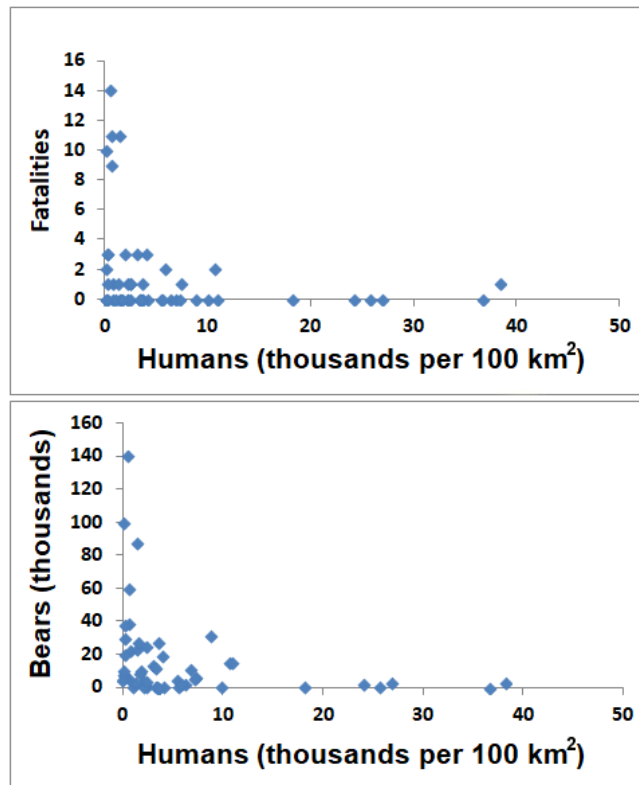


Figure 7. Black bear fatalities and abundance vs. human density in each jurisdiction

Discussion

Bombieri et al. (2019) published an analysis of attacks by brown bears for years 2000-2015 across the species' entire range. We will address their findings after discussing our own.

Temporal Variation

Human abundance: In theory, one might assess the number of human fatalities relative to the number of humans living within an X km radius of each attack site. However, for now it would be prohibitively expensive to dig out census data for each municipality of each state or province where a fatality occurred, during the appropriate year, then to estimate human density within that radius. Indeed, one might have to test several radii. Nor did we find data for most jurisdictions on the numbers of people likely to encounter bears within each state, province, or continental jurisdiction. Hence, like

Herrero and his colleagues (Herrero & Higgins 1999, 2003; Herrero et al. 2011; Smith & Herrero 2018), we instead regressed conflict rate against the entire numbers of humans residing in each jurisdiction.

Given the roughness of Hristienko & McDonald's (2007) estimate that bear abundance increased 18% between the late 1980's to 2001 continent-wide, that estimate is not significantly different than the 20% increase in human abundance between 1988-2001 (values interpolated from decadal census figures: Census.gov for the USA; Statistics Canada 2018). Whether bear and human numbers have continued increasing at similar rates is unknown.

Findings by Herrero, Smith and colleagues. Our analysis updated that by Herrero et al. (2011) on black bears, then extended it to grizzly bears. So we summarize their findings here before contrasting them with our own. During the 11 decades between 1900-2009, 86% of 63 fatal black bear attacks reported by Herrero et al. (2011) occurred during the last 5 decades. Human abundance north of Mexico increased: 382% (= 81.5 to 310 million) between 1900-2009, 58% between 1960- 009, and 25% between 1980-2009 (Census.gov; Statistics Canada 2018).

Human abundance accounted for 92% of variation in black bear attack rate per decade at both the continental scale and for the state of Alaska ($P < 0.0000$; Herrero et al. 2011; Smith & Herrero 2018), as well as 97% ($P < 0.000$) of variation in attack rate for Alberta (Herrero & Higgins 2003). (Values presented by those authors differed slightly from these, because we prorated conflict rates to the end of the last decade which they assessed; see Methods).

These were all positive linear relationships, which Herrero and his colleagues attributed to increasing human-bear encounter rates per decade. The constant slope of each regression line implied that, on average, rates of encounter and of attack per person per decade varied only randomly around consistent means. This could be interpreted as evidence that countermeasures against conflicts have merely kept per capita rates of encounter and attack from increasing. However, this consistency among jurisdictions should be interpreted cautiously, given that the conflict metrics reported differed among jurisdictions. (a) *Alaska*: attacks by grizzly and black bears which inflicted injuries ranging from slight to fatal (Smith & Herrero 2018); (b) *British Columbia and Alberta*:

serious and fatal attacks by grizzly and black bears combined (Herrero & Higgins 1999, 2003); (c) *continent-wide*: fatalities inflicted by just black bears (Herrero et al. 2011). A comparable analysis of grizzly-bear inflicted fatalities had not yet been done until our study.

Comparison among the data sets assessed by Herrero and his colleagues would be more revealing if the authors separated conflict rate by species and injury severity. Whether any of the unreported metrics deviated from linearity isn't known. This could be tested for BC and Alberta if the assessments by Herrero & Higgins (1999, 2003) were updated, adding data for the past two decades. Hopefully, the Alaskan and Canadian studies will eventually be updated with separate plots for (a) fatal attacks, (b) serious attacks, (c) lesser maulings, and (d) non-injurious aggressive encounters, so that each of these categories of conflict can be compared within and among bear populations and species. Whether there are enough data in any of those subcategories to reveal reliable trends remains to be seen.

Bear Abundance: Whereas the rise in conflict rates can be traced back at least to 1900 (Herrero et al. 2011, Smith & Herrero 2018), even moderately reliable estimates of bear abundance extend back only a few decades for most states and provinces (Hristienko & McDonald 2007). Continental scale summaries extend back only to the late 1980s (Hristienko & McDonald 2007), precluding regression of fatal rate against abundances of bears since 1900. Nevertheless, as was obvious even before bear population sizes could be estimated closely: through at least the first half of the 20th Century, bear populations in many states and provinces were decimated by over-hunting, predator control, or habitat loss and degradation. In some jurisdictions, bear abundance is still low; in others, where bear hunting was suspended for a few decades, abundance has been increasing (Hristienko & McDonald 2007). We attribute the presence of a positive correlation between fatalities vs. bear abundance but not vs. bear density to the fact that density calculations are based on total land area of each jurisdiction, not just the fraction of the jurisdiction occupied by bears – information which we lack

Black bear population size estimates for the late 1980s were contrasted with those as of 2001 by Hristienko & McDonald (2007). Between these periods, black bear abundance north of Mexico increased by approximately 18%. Black bear abundance was apparently

stable or growing from the late 1980s through 2001 in all Canadian provinces and in most states with a bear population. Bear hunting was legal in all of the Canadian provinces with black bears and in 28 states. Only one of those states – West Virginia, which has one of the densest black bear populations in North America – reported serious human-black bear conflict rates. Serious conflicts – but not human fatalities – were also reported for the un hunted population in Maryland, whose growth rate was unknown, as well as for the rapidly growing un hunted populations in Nevada and Florida (Hristienko & McDonald 2007). One fatality occurred in New Jersey, where growth rate was also high due to curtailment of hunting pressure for many years. In a jurisdiction with a growing bear population, bear numbers may increase both in habitat long occupied by bears, and in surrounding habitat where bears have long been absent – habitat where both bears and people are likely to be less adept at coexistence and where humans are less comfortable with it. The faster bear abundance grows, the more obvious the rise in conflicts.

Grizzly bear numbers and grizzly-human conflicts in the continental USA – mainly in and around Glacier National Park (Montana) and Yellowstone National Park (Montana, Idaho and Wyoming) – have also been growing since the species was Listed as Threatened in 1975 [USFWS 2016]. Grizzly abundance appears to be stable or declining in Canada and Alaska. There are no “censuses” to quantify any trend in Alaskan bear numbers. However, greatly reducing bear abundance is the State’s chosen method of trying to increase ungulate populations of – a method implemented through sport hunting and through the “intensive management” predator control program (ADF&G 2019).

Black vs. grizzly bears. Given the similarity of regression curves we found for black vs. grizzly bears across North America, we hypothesize that since 1900, grizzly and black bear fatality rates have been responding to the same set of risk factors in similar ways – in accordance with the many morpho-physiological, behavioral and ecological similarities between the species, as well as with their extensive range overlap in the northwestern United States and Canada. Also, many human impacts, including measures to prevent or resolve conflicts (e.g., pepper spray) have affected both species.

Safety precautions. The sigmoidal curve in Figure 2b suggests that per capita fatality rate switched from accelerating to decelerating (i.e., the inflection point occurs) in the 1970s. This coincides with the major continent-wide increase in bear safety precautions,

including limiting bear access to human food and garbage, following the deaths of the two women in Glacier National Park during 1967 (see Herrero 1985, Herrero and Higgins 1999). Gradual leveling of the fatality rate curves, apparently followed by decline, might be the first quantitative measure of how successful these and other precautions have been continent-wide.

Motivation. The strong positive correlation between fatality rates inflicted by these two species might be surprising given their difference in motivations. Granted that both species have killed similar numbers of people; and both species have killed people as prey. However, predatory fatalities predominate among black bears, but not grizzly bears (Herrero 1985; Herrero & Higgins 1999, 2003; Herrero et al. 2011). If a bear perceives someone as a threat or rival, a grizzly might kill that person; but a black bear would normally inflict no more than slight wounding, if any at all. This does not, of course, mean that grizzly bears are less predatory. Combining data from three studies (Herrero & Higgins 1999, 2003; Smith & Herrero 2018) indicate that predation rate per bear is about twice as high for grizzlies. If fatality risk was primarily a function of motivation, one might expect a strong correlation between predation rates by both species, but only a weak correlation between predation rate by black bears vs. total fatality rate by grizzly bears. Yet this latter correlation is actually strong, suggesting that fatality rate depends less on the bear's motivation than on circumstances, possibly including (a) size and strength of the bear, (b) how people behave during encounters or to avoid encounters, or (c) on the speed and quality of their medical care.

Contradictory trends. Over a number of decades, conflict rates with black and grizzly bears in Alberta and Alaska rose along with human abundance, as did fatality rates inflicted by black bears continent wide. In Nevada, Florida, and New Jersey, rates of non-fatal conflicts rose along with rising numbers of both humans and bears. Human fatality rates did not rise in Nevada or Florida, but one person was killed in New Jersey.

The trend in Yellowstone National Park (YNP) was reversed. When Gunther (in Garshelis et al. 2017:34-36) contrasted conflict levels during 1931-1959 with those during 1960-2012, he found steep declines in property damage and human injuries. Whereas a large number of food-conditioned or habituated bears were executed during the late 1960s and 1970's (Craighead et al. 1995; Lon Garrison pers. comm.; Jack Dean

pers. comm.; Gerald Richmond pers. comm.), executions have seldom been necessary since strict implementation of food and garbage containment procedures. Even bears that severely mauled or killed a human were usually spared if the attack was defensive – a restraint much rarer in jurisdictions where bears were not recovering under protection of the Endangered Species Act. Yellowstone's conflict reduction also occurred despite (a) rising numbers of human visitors to the Park and its environs (Gunther in Garshelis et al. 2017:34-36), and despite (b) at least doubling the numbers of grizzly bears within the Greater Yellowstone Ecosystem (USFWS 2016). This decline in conflicts – i.e., in incidents of property damage and of human injury – occurred both per unit time and per million visitors to YNP (Gunther, in Garshelis et al. 2017:34-36). Both metrics also appear to have declined per hundred grizzly bears since at least the 1970's. Similar success has been reported for Glacier National Park (GNP; Gniadek & Kendall 1998; Herrero & Higgins 1999).

Why did conflict rate per human decline in YNP and perhaps GNP, but increase at the scales of state, provincial and continental jurisdictions? Three hypotheses have been offered: (a) bear access to anthropogenic foods and other attractants was more thoroughly minimized in these national parks (see Mazur 2015). Not only does the National Park Service (NPS) exert tight control over bear access to attractants, but particularly great efforts have been made in Parks containing grizzly bears – i.e., in Yellowstone and Glacier National Parks. Furthermore, NPS has also been almost as thorough as other federal agencies (e.g., US Forest Service) and state wildlife management agencies in eliminating food-conditioned or habituated bears (Mazur 2015). (b) Degradation, fragmentation and shrinkage of bear habitat has tended to be much more limited within national parks than outside them. (c) Disturbance of bears by hunting (of bears, ungulates, and other game) outside of Parks might have reduced bear tolerance for humans in those areas.

Abundance of which humans? When Gunther (in Garshelis et al. 2017:34-36) reported major declines in conflict metrics despite increased human abundance, these humans were all visitors to YNP, and thus potentially at risk of a bear encounter. By contrast, when Herrero & Higgins (2003), Herrero et al (2011) and Smith & Herrero

(2018) regressed conflict rates on human abundance, these humans were the whole populations of Alberta, Alaska, and North America north of Mexico, respectively.

Relationships between attack rates vs. human abundance at the state, provincial and continental scales would be easier to interpret if one could regress total numbers of conflicts (separately for each kind of conflict) vs. numbers of people likely to conflict with a bear, and numbers of bears likely to conflict with humans. However, we found no records of these variables being documented for any jurisdiction. And we have found few maps showing how bear density varies within any state or province even currently, much less historically. And although gathering comparable data on human density might be possible, it is not economically feasible. Hence our focus on human abundance at larger geographic scales.

If human abundance throughout North America or just north of Mexico were not reliable indices of how human abundance affects bears, why would variation in human abundance at those scales account for $\geq 99.6\%$ of variance in fatalities? Is human abundance merely a serendipitous correlate for some other kind of influence on bears? The fact that we do not understand the exact connection between fatality rates vs. human abundance does not negate the relationships found. Rather, it should stimulate future research to identify the connection. For now, we cannot reject the null hypotheses – inherent in all three assessments by Herrero and his colleagues (Alberta, Alaska, and continent-wide) – that encounter rates were highly positively correlated with overall abundance of human residents in each jurisdiction, despite differences among jurisdictions in season tourist influx.

Fatality risk per person (F) is the mathematical product of fatality risk per encounter (F/E) multiplied by encounter rate per person (E): $F = (F/E)*E$. If both fatality rate per person and encounter rate per person were indeed stable or declining, then fatality risk per encounter could not have been increasing – contrary to speculation that bears have become more dangerous.

That contradiction is supported both by the sigmoidal shape of our curves, and by the fact that human abundance accounts for virtually all (>99%) variation in total fatality rates for both species combined. Although rising black bear abundance in some jurisdictions statistically accounts for part of the increase in conflict rates, there is no

evidence that they account for rising black bear inflicted fatality rates, given that fatality rates rose almost entirely where bear populations were relatively stable. On the other hand, rising grizzly abundance and geographic distribution in the vicinity of Yellowstone National Park apparently is one cause of increased human injuries in that area (USFWS 2016).

Alternate hypotheses

Bear densities and habitat stability. The rates of bear inflicted fatalities have been especially high in Canadian provinces and Alaska. High fatality rates in Alaska are likely explicable by the high abundances of black bears (~100,000) and brown bears (~32,000) (Smith & Herrero 2018); indeed, there is virtually no part of Alaska which is habitable by people, that is not also inhabited by bears. Furthermore Alaskans make heavy use of bear habitat for economic and recreational purposes. The situation is similar in the Yukon Territory where bear density is high relative to the human population. Ratios of humans to bears are higher in British Columbia, Alberta, and especially in more easterly provinces which host only black bears. We speculate that bear-human conflicts in Canada and Alaska, and to a lesser extent the northern Rocky Mountain states, are exacerbated by (a) insufficient diversity of their most important foods – e.g., prey, fruit and nuts – to compensate for dramatic annual differences in supplies of those foods; (b) greater reliance on predation in northern habitats; (c) habituation, which as Herrero et al. (2011) point out, is likely to be especially low in Canada and Alaska due to the historically low opportunities for bears to encounter bear-tolerant humans.

High rates of brown bear inflicted fatalities in Montana and Wyoming may reflect little more than that (a) these are the only states south of Canada with a substantial grizzly bear population, and that (b) habitats surrounding Yellowstone and Glacier National Parks are heavily sport hunted for ungulates, leading to frequent dangerous encounters between hunters and grizzlies (Herrero 1985; USFWS 2016). Although it is conceivable that rising conflict rates by both species up until recently were linked to progressive deterioration of habitat, due for instance to climate change or other human impacts, that would not explain why fatality rates have been declining in recent decades, both per unit time and per million humans. However, we cannot reject the hypothesis that climate

warming has improved food supplies in northern habitats where most black bear fatalities have occurred historically.

Medical care. Another reason for waning fatality rate per decade could be improved medical care for victims who survive being attacked. However, if improved care had markedly increased victim survival rate, one would expect the correlation in fatality rates between black vs. grizzly bears to have increased over time – given the bear’s species doesn’t affect care quality. Yet just the opposite has occurred. During the past two decades, fatality rates for these species seem to have been decoupling and individually deviating farther from the sigmoidal pattern formed when fatality data on the two species are summed.

Completeness of conflict records. For British Columbia and Alberta from the 1960s - 1990s, Herrero & Higgins (1999, 2003) attempted to obtain complete records on both fatal and serious injuries by black and grizzly bears. So resolution of whether attack rate rose faster than human abundance in these provinces could best be achieved by updating those studies with data from the following two decades.

Records of fatal or serious maulings in Alaska during 1900-2015 (Smith & Herrero 2018) are both of longer duration and more current, as well as even more thorough – excluding some cases where conflict led someone to kill the bear DLP (defense of life or property), records which the Alaska Department of Fish & Game declined to share with Smith & Herrero. Those authors' records of lesser injuries might also be fairly complete. By contrast their records of non-injurious aggressive encounters – i.e., “incidents” – are far from complete, as exemplified by the fact that those records do not include our own experiences. Nevertheless, their records are likely to encompass a high enough percentage of all incidents to constitute a reasonably representative sample. Whether plots for any subcategories of injury severity would be linear or sigmoidal has yet to be revealed.

That Herrero et al's (2011) data set was incomplete is demonstrated by the additional cases we found. That incompleteness apparently distorted the relationship between black bear fatality rate vs. human abundance, making a sigmoidal relationship appear nearly linear. Bombieri et al. (2019) have accumulated a much larger number of records than we found for grizzly attacks in North America for 2000-2015; but it is not clear whether

the number of fatalities they found was also higher, and if so whether it confirms the sigmoidal pattern.

The most likely source of distortion in our results would be rising completeness of discoverable fatality records over time. Incompleteness of discoverable records during the early decades of the 20th Century would have led to underestimation of how fast fatality rate rose per decade and per million humans. However, even if one ignores fatality rates for the first two or three decades, this would cause negligible change in shape of the data plot for later decades. Furthermore, we have no basis for thinking that incompleteness of discoverable records has been a significant factor since the middle of the 20th Century. Nor could such a bias explain why fatality rates relative to human abundance have been declining since the 1970s. So the sigmoidal shape of the trends we found is even less likely than the linear trends reported by Herrero and his colleagues to be a sampling artifact, which could have masked any increase in fatal attack rate per bear or per encounter.

Multivariate influences on rates of human-bear conflicts and fatalities

Summarizing, three major factors have been proposed as possible causes of rising conflicts: (a) changes in conflict risk per bear or per human; (b) rising numbers of bears; and (c) rising numbers of humans. Conflict risk per bear could rise due to changes in the behavior of bears towards humans, due for instance to habituation, alienation, hunting, food-conditioning, or habitat change (degradation, fragmentation and shrinkage). Conflict risk per human could rise or fall due to changes in the behavior of humans towards bears – e.g., changes in hunting pressure, increased precautions by people to avoid conflicts, resolving conflicts with pepper spray and other deterrents, or altered management practices. The relative importance of these factors apparently varies among populations, although this has yet to be verified by multivariate statistical analysis.

Geographic Variation Within North America

Differences in bear abundances and densities among jurisdictions at the beginning of the 21st Century (data for 2001 in Hristienko & McDonald 2007) are most likely to be representative of historic differences for populations which have not been drastically reduced. We speculate that this is why geographic variation in fatal attack rate was positively correlated with black bear abundance in each jurisdiction mainly when

comparing among populations with at least 30,000 bears. Fatality rate among smaller – largely remnant – populations was unrelated to recent population size. On the one hand, during 1900-2019 there were no fatal attacks in California, Oregon, and Idaho – each with >20,000 black bears, at densities >50 bears/1000 km² (Figure 4). On the other hand, 3 people were killed in Colorado (8,000 – 12,000 bears, >25 bears/1000 km²), and 1 person was killed in each of the four surrounding states (Wyoming, Utah, Arizona and New Mexico) with a combined population of 15,000 to 18,500 bears, at a mean density <25 bears/1000 km². Any correlation between fatality rates vs. bear density is further obscured by the fact that bear density estimates are means for each entire jurisdiction, not for that fraction of each jurisdiction which is occupied by bears.

Summarizing: Both the temporal and geographic positive correlations documented for black bear-inflicted fatalities vs. bear abundance, are consistent with the hypothesis that having more bears tends to increase fatalities and lesser conflicts. However, most of the rise in fatalities occurred in jurisdictions where black bear populations have been fairly stable; only one occurred where bear abundance increased markedly during recent decades.

Geographic Variation Globally

Temporal and geographic trends: Our current analysis – which considers fatalities inflicted by brown and black bears in North America during 1900-2019 – builds on our previous (Stringham & Rogers 2017) assessment of fatal vs. non-fatal attacks in southwestern Canada (Alberta and British Columbia) vs. Scandinavia. That 2017 study combined scientific data from the late 20th Century with more anecdotal information dating back to the early 1800's in North America and to the late 1700's in Scandinavia. By contrast, Bombieri et al. (2019) considered both fatal and non-fatal attacks by just brown bears across their full geographic range during 2000-2015. They did not provide separate statistics on fatal vs. non-fatal attacks in a way that would reveal whether they found any records of fatal attacks that we missed, or vice versa.

Given that we and Bombieri et al (2019) worked from partially overlapping data sets, it is not altogether surprising that there are major points of agreement – e.g., that variation in attack rates were due primarily to time (temporal trend), abundances of bears and abundances of humans. They also agree that attack rates were positively correlated with

bear abundance, especially as bear abundance increased over time. But neither they nor we were able to restrict this to those bears which actually encountered humans or were likely to do so. Perhaps brown bear habitat in Europe is so heavily populated with humans that most brown bears are likely to encounter humans; but in North America – especially Alaska and northern Canada – there are vast areas where encounters are uncommon. Furthermore, as noted above, the temporal increase in black bear inflicted-fatalities occurred almost entirely where the black bear population was relatively stable.

Given the vast differences in temporal and geographic scales between our studies versus that by Bombieri et al. (2019), it is also not surprising that their results differ from ours in other ways. On the one hand, they agree that attack rate is likely to be positively correlated with encounter rate, which is likely to be highly positively correlated with human population density in each jurisdiction – as initially documented for brown and black bears by Herrero & Higgins (1999, 2003), Herrero et al. (2011), and Smith & Herrero (2018), and as verified in this new study, except for the fact that our larger data set indicates that the relationship is not linear by sigmoidal. However, none of us has had data on numbers of people who encounter bears or who are likely to do so; that is merely assumed to be strongly positively correlated with the density of human residents (not counting seasonal tourists) in each jurisdiction.

The records compiled by Bombieri et al. (2019) indicate that the rate of attacks (fatal and non-fatal combined) by brown bears increased in North America and Europe during 2000-2015. Our records for North America show the same thing for fatal brown bear attacks during 2000-2019. However, the relatively low fatality rate (11) during 2000-2009 in North America followed a rate of 15 fatalities in 1990-1999, which was almost as high as the 2010-2018 rate of 16, which we prorated to 17 for the full decade 2010-2019. Considering ups and downs during previous decades, a sequence of 15, 11, 17 fatalities per decade cannot be considered indicative of a rising trend.

In North America, fatal attacks by both brown and black bears increased steadily, geometrically, during 1900-1980. From 1930-1980, fatalities by black bears always exceeded those by brown bears, as was also true during the 2000 decade. However, during the decades of 1990 and 2010, fatalities by brown bears exceeded those by black bears. In other words, during the decades of 1990-2010, variation in fatalities by black

bears has not paralleled that for brown bears as in earlier decades; rather, it has mirrored the rates for brown bears, with the result that the net rate of fatalities for the two species together has been declining. We have no theoretical basis for assuming that the apparent compensatory variations in fatalities by these two bear species is due to anything but chance.

Aggressiveness:

The data of Bombieri et al. (2019:Table 1) indicate that rates of attack per year per 1000 bears were nearly 6-fold higher in Europe (1.2) than in North America (0.21). That confirms our (Stringham & Rogers 2017) earlier study in which we contrasted attack data from southwestern Canada (Alberta and British Columbia, 1960-1997) versus Scandinavia (Sweden and Norway, 1976-1995). We calculated that: (a) The rate of non-fatal maulings per 1000 brown bears was 2-fold higher in Scandinavia than in Canada. (b) The rate of predatory attacks per million bear-years was up to 3-fold higher for Scandinavian brown bears (8 - 11) than for North American brown bears (3.4), and up to 10-fold higher than for North American black bears (<0.7). Those results contradicted claims that European brown bears are less aggressive than those in North America.

Bombieri et al's (2019:Table 1) data reveal a positive correlation between attack rate per brown bear vs. human population density in both North America and Europe (Figure 8), suggesting that brown bears are more likely to attack people in jurisdictions with a high human population density. North American states and provinces with brown bears have far lower human densities than countries with brown bears in Europe. Hence, the positive correlation between attack rate per bear vs. human density implies that attack rate per bear per person is actually lower in Europe than in North America.

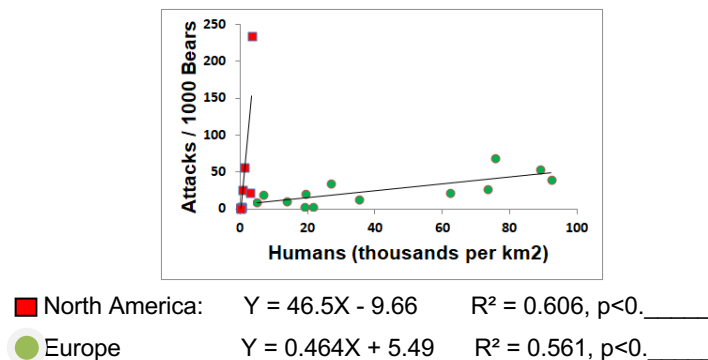


Figure 8. **Attack rate per 100 brown bears relative to human population density** (data from Bombieri et al. 2019:Table 1)

Furthermore, brown bears were less likely to kill the people they attacked in Europe than in North America. The percentage of attacks that were fatal was lower in Europe (5.7% = 16/283) than in North America, where percent fatality was 13.1% (= 24/183; 9.7% = 9/93) in Alaska and British Columbia, where many bears live on sea coasts and are known for their especially high tolerance for one another and for humans (Herrero et al. 2005, Smith et al. 2005), compared to 16.7% (= 15/90) for other North American populations. Indeed, there were no fatalities in 8 European countries (Norway, Finland, Slovakia, Slovenia, Spain, Croatia, Italian Alps, and Estonia which had a total of 97 attacks. Most European attacks (131) and fatalities (11) both occurred in Romania, where the fatality rate was 8.4%. Unlike the previous data set we analyzed, this one is consistent with claims that brown bears are less aggressive in Europe than in North America.

However, one should also take into account other factors. Whether or not there is a temperament difference between brown bears on these continents, there is a well documented size difference (). Although we'd predict that larger, stronger bears would be more likely to inflict more severe injuries during attack, we know of no data contrasting victim survival rate vs. size of the attacking bear. Similarly, the even lower rates of serious or fatal injury from black bear attacks (Herrero & Higgins 1999, 2003; Smith & Herrero 2018) might be partly a result of their even smaller body sizes.

Given these uncertainties, we reiterate our 2017 caution that differences in temperament and body size are not the only factors affecting rates of attack and fatality. One should also consider relative commonness of factors which promote attack: surprising a bear, distance between bear and victim when attack began, visibility, bear population size, human population size, habitat, habituation and the lure of human foods, whether the victim was accompanied by a dog, how many people accompanied the victim (i.e., group size), victim's activity when attacked (e.g., gathering food, tending livestock, or hunting), wounding the bear, or the bear defending its cubs, its prey carcass, or its den site.

Bombieri et al. (2019) also echo our hypothesis that where bear populations were relatively stable vs. increasing, conflict rates might be higher if a bear population is

expanding into new habitat where people are less familiar with methods of minimize conflict or less willing to implement those methods.

Management Implications

Past successes

In national parks and some other government lands, federal or state officials can exert enough pressure on the public to minimize bear access to anthropogenic foods and other attractants. National Park Service personnel also strive to minimize habitat loss, degradation, and fragmentation, as well as harassment or killing of wildlife by the public. Although managers may kill conflict bears even in national parks, this has been more restrained than in other federal or state jurisdictions. That suite of measures has proven highly effective at reducing conflict levels, as is particularly well documented for Yellowstone National Park (YNP). Gunther (in Garshelis et al. 2017:34-36) revealed dramatic declines in conflicts per year and per million visitors when he contrasted rates up through 1959 vs. later years.

By contrast, conflicts have continued to rise outside of national parks in the United States and Canada. That occurred despite intensive efforts by state and federal agencies, as well as NGOs such as the BEAR League and Bear Smart, to reduce bear access to anthropogenic food and other attractants. Data presented for British Columbia (Herrero & Higgins 1999), Alberta (Herrero & Higgins 2003) and Alaska (Smith & Herrero 2018) imply that conflict-minimization efforts have succeeded mainly in preventing a rise in conflict rate per human. On the other hand, the sigmoidal relationships we found are consistent with the alternate hypothesis that conflict rate per person has actually been declining, perhaps as a result of countermeasures.

Innovation, not complacency

Assuming that the recent decline in fatality rates is indeed a result of countermeasures, this evidence that past management investments have been successful should warrant more investment, not complacency. No crystal ball or a computer model is needed to predict that the number of people exposed to bears of both species will continue to grow, along with any further increases in sizes of bear or human populations, moderated by changes in the amount of time per capita that people recreate, work or reside in bear habitat. Black bear abundance is increasing in several states and Canadian

provinces, as bear populations recover from decades of excessive hunting, persecution, or habitat loss (Garshelis and Hristienko 2006, Hristienko and McDonald 2007).

Grizzly populations in the vicinity of Yellowstone and Glacier National Parks have also grown since 1975 when they were declared a Threatened species (USFWS 2016), although there is evidence that the Yellowstone population has been declining again over the past decade (Mattson 2017). Renewed hunting pressure on grizzlies outside of Yellowstone National Park, originally scheduled to begin in 2019, may well increase attack risk. Encounter probability and risk per encounter could also be increased by continued habitat loss – i.e., shrinkage, degradation, and fragmentation. All else being equal, these factors would tend to increase human fatalities per decade, and probably fatalities per person per decade.

Minimizing any resurgence in fatalities, and preferably of continuing to reduce per capita fatality rate, will require even greater investment in preventative measures. Continued efforts to promote proper storage of anthropogenic foods and other attractants should be supplemented with greater investment in finding ways (e.g., using tasers) to terminate conflict behavior without killing the bear. Before managers can limit killing to bears which pose substantial risk, managers would need to be able to better judge risk; and they need regulations which protect them if they spare the life of a seemingly low-risk bear which later harms someone (Stringham 2012).

Close attention should also be paid to anomalous situations which appear to contradict conventional wisdom. For example:

- a) Despite concerns that conflicts are usually exacerbated when bears obtain human-source food, recent experiments demonstrate that properly conducted diversionary baiting can be highly effective, whether it is done on a long-term basis (Rogers 2011) or just during a major famine (e.g., Stringham and Bryant 2015, 2016; Garshelis et al. 2017).
- b) Likewise, some private individuals have fed bears for years, if not decades, without the bears becoming any more conflict-prone than unfed bears; on the contrary, having access to feeding stations where they are safe from aggression by dogs and humans keeps some bears out of conflicts (Becklund 1999; Stringham 2002, 2009; Rogers 2011; Piche 2015; Kilham 2013; Vandergaw pers. commun. 2011). However,

feeding bears needs to be done with great care. It can attract bears into areas (e.g., neighborhoods) where they are not wanted by most people; and it can increase probability of dangerous encounters. Indeed, one woman – Donna Munsen – was killed and eaten by a black bear at her feeding station near Ouray, Colorado in 2007 (Bunch 2009).

- c) Some state wildlife management agencies contend that baiting bears to facilitate hunting them does not food-condition survivors; or if it does food-condition survivors, doing so does not increase likelihood that survivors will conflict with humans.
- d) On some Alaskan salmon streams, such as the Kenai Peninsula's Russian River, black and brown bears scavenge salmon scraps from among hundreds of anglers. Yet there has been little aggression by Russian River bears; and what has occurred has been mainly defensive aggression triggered by human belligerence. In other words, much of the risk produced by close human-bear proximity arises because bears are too afraid of human aggression, and because the people they encounter are either unaware of how to behave around bears, or are unwilling to do so. Safety in such situations could be enhanced by educating humans on how to coexist with bears, and by educating bears to treat humans somewhat like higher-ranking bears that will not attack them without provocation, but will retaliate if provoked (Stringham 2009).
- e) Winning the trust of bears without promoting disrespect has been highly effective in areas of Alaska where bears of both species are regularly viewed at distances <100 m, often without any barrier protecting humans from bears (e.g. Stringham 2008, 2009, 2011). Millions of people have viewed bears under these conditions with virtually no one being injured.

Research and hypothesis testing

These contradictions to conventional wisdom were not presented herein to argue that conventional wisdom is universally wrong, but to demonstrate that it is not universally right – that there are situations where intervening factors alter the effects of habituation and food conditioning. Historically, attempts to publicize such contradictions have triggered persecution. Attempts to understand contradictions through experimental

research and hypothesis testing have been opposed. Research permits have been refused or withdrawn. The oft-stated reasons for refusal have been rigid beliefs that it could not work; it would be a waste of time and resources; it would endanger the public. However, where experiments have been conducted anyway, none of the dire predictions materialized. Centralized agencies are not necessarily as knowledgeable about local conditions as are the people who live and work there, including professional wildlife biologists or stewards such as members of the bear conservation NGOs – e.g., the BEAR League and Bear Smart. Although some of the independent studies by NGOs have been successful, success could have been even greater if conducted with agency assistance during planning and implementation phases.

Agencies should not be troglodytes, but leaders in innovation – both instrumental, cybernetic, and conceptual. They should not feel a need to defend preconceptions rather than verifying and updating them. They should not view challenges to conventional thinking as challenges to their authority, expertise, or credibility. Especially in a democracy, credibility suffers when alternative viewpoints and new insights are ignored, denied, stifled, or attacked. Conversely, credibility is enhanced when an agency (a) welcomes alternative ideas, (b) transforms them into competing hypotheses which can be empirically verified, (c) fosters verification tests, and (d) adapts policies to the outcome of those tests.

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Literature cited

ADF&G 2019.

<https://www.adfg.alaska.gov/index.cfm?adfg=intensivemanagement.main>. Accessed 2019/8/8.

Becklund, K. 1999. *Summer with the bears: six seasons in the north woods*. Hyperion, New York, NY.

- Bombieri, G., G. Bombieri, G. Bombieri, J. Naves, V. Penteriani, N. Selva, A. Fernández-Gil, J. V. López-Bao, H. Ambarli, C. Bautista, T. Bespalova, V. Bobrov, V. Bolshakov, S. Bondarchuk, J. J. Camarra, S. Chiriac, P. Ciucci, A. Dutsov, I. Dykyy, J. M. Fedriani, J. Naves, V. Penteriani, N. Selva, A. Fernández-Gil, J. V. López-Bao, H. Ambarli, C. Bautista, T. Bespalova, V. Bobrov, V. Bolshakov, S. Bondarchuk, J. J. Camarra, S. Chiriac, P. Ciucci, A. Dutsov, I. Dykyy, J. M. Fedriani, A. García-Rodríguez, P. J. Garrote, S. Gashev, C. Groff, B. Gutleb, M. Haring, S. Härkönen, D. Huber, M. Kaboli, Y. Kalinkin, A. A. Karamanlidis, V. Karpin, V. Kastrikin, L. Khlyap, P. Khoetsky, I. Kojola, Y. Kozlow, A. Korolev, N. Korytin, V. Kozshechkin, M. Krofel, J. Kurhinen, I. Kuznetsova, E. Larin, A. Levykh, V. Mamontov, P. Männil, D. Melovski, Y. Mertzanis, A. Meydus, A. Mohammadi, H. Norberg, S. Palazón, L. M. Pătraşcu, K. Pavlova, P. Pedrini, P. Y. Quenette, E. Revilla, R. Rigg, Y. Rozhkov, L. F. Russo, A. Rykov, L. Saburova, V. Sahlén, A. P. Saveljev, I. V. Seryodkin, A. Shelekhov, A. Shishikin, M. Shkvyria, V. Sidorovich, V. Sopin, O. Støen, J. Stofik, J. E. Swenson, D. Tirski, A. Vasin, P. Wabakken, L. Yarushina, T. Zwijacz-Kozica, M. M. Delgado. 2019. *Scientific Reports*. 10 pp. 9:8573 | doi.org/10.1038/s41598-019-44341-w
- Bunch, J. Autopsy: bear killed woman near Ouray. *Denver Post* 8/11/2009.
- Census.gov. 2018. [census.gov/search-results.html?q=alaska+%2B+population+%2B+1880&search.x=0&search.y=0&page=1&stateGeo=none&searchtype=web](https://www.census.gov/search-results.html?q=alaska+%2B+population+%2B+1880&search.x=0&search.y=0&page=1&stateGeo=none&searchtype=web)
- Garshelis, D. L., S. Baruch-Mordo, A. Bryant, K. A. Gunther and K. Jerina. 2017. Is diversionary feeding an effective tool for reducing human–bear conflicts? Case studies from North America and Europe. *Ursus* 31-55. DOI: <http://dx.doi.org/10.2192/URSU D-16-00019.1>.
- Garshelis, D. L and H. Hristienko. 2006. State and provincial estimates of American black bear numbers versus assessments of population trend. *Ursus* 17:1-7.
- Gniadek, S.J., and K.C. Kendall. 1998. A summary of bear management in Glacier National Park, 1960-1994. *Ursus* 10:155-159.
- Gunther, K. A. 1994. Bear management in Yellowstone National Park, 1960-93. *Ursus* 9:549-560.

- Gunther, K. A., M. A. Haroldson, K. Frey, S. L. Cain, J. Copeland, and C. C. Schwartz. 2004. Grizzly bear-human conflicts in the Greater Yellowstone ecosystem, 1992–2000. *Ursus* 27:10–22.
- Herrero, S. 1985. *Bear attacks: their causes and avoidance*. Lyons and Buford. New York, New York, USA.
- Herrero, S., and A. Higgins 1999. Human injuries inflicted by bears in British Columbia 1960–1997. *Ursus* 11:209–218.
- Herrero, S., and A. Higgins 2003. Human injuries inflicted by bears in Alberta 1960–1998. *Ursus* 14:44–54.
- Herrero, S., A. Higgins, J. Cardoza, L. I. Hajduk, and T. Smith. 2011. Fatal Attacks by American black bear on People: 1900–2009. *Journal of Wildlife Management* 75:596–603.
- Hristienko, H., and J. E. McDonald. Jr. 2007. Going into the 21st century: a perspective on trends and controversies in the management of the American black bear. *Ursus* 18:72–88.
- Kilham, B. 2013. *Out on a limb: what black bears have taught me about intelligence and intuition*. Chelsea Green Publishing, White River Junction, Vermont.
- Mattson, D. L. 2017. <https://www.grizzlytimes.org/the-numbers-game>.
- Mazur, R. 2015. *Speaking of Bears*. Falcon Press, Helena, MT.
- Obbard, M. E., E. J. Howe, L. L. Wall, B. Allison, R. Black, P. Davis, L. Dix-Gibson, M. Gatt, and M. N. Hall. 2014. Relationships among food availability, harvest, and human-bear conflict at landscape scales in Ontario, Canada. *Ursus* 25:98–110.
- Piche, A. 2015. *The beardude story: data vs. dogma*. A Createspace Publication.
- Raithel, J. D., M. J. Reynolds-Hogland, D. N. Koons, P. C. Carr, and L. M. Aubry. 2017. Recreational harvest and incident-response management reduce human–carnivore conflicts in an anthropogenic landscape. *Journal of Applied Ecology* 2017 54:1552–1562
- Rogers, L. L. 2011. Does diversionary baiting create nuisance bears and jeopardize public safety? *Human–Wildlife Interactions* 5:287–295.
- Sheldon, G. 1998. *Bear attacks, the deadly truth*. Pallister Publications, Hagensborg, BC.

- Sheldon, G. 2001. Bear attacks 2: Myth and reality. Pallister Publications, Hagensborg, BC.
- Statistics Canada 2010: <https://www150.statcan.gc.ca/n1/pub/98-187-x/4151287-eng.htm>
CanSim Tables 075-0001 (1900-1970) and 051-0001 (1971-present)
- Stringham, S. F. 2008. Alaska magnum bear safety manual. WildWatch, Soldotna, AK.
- Stringham, S. F. 2009. When Bears Whisper, Do You Listen? WildWatch, Soldotna, AK.
- Stringham, S. F. 2011. Aggressive body language of bears and wildlife viewing: a response to Geist (2011). *Human-wildlife Interactions* 5(2):177-191.
- Stringham, S. F. 2012. Managing risk from bears and other potentially lethal wildlife: predictability, accountability, and liability. *Human-wildlife Interactions* 7(1):5-7.
- Stringham, S. F., and A. Bryant. 2015. Distance-dependent effectiveness of diversionary bear bait sites. *Human-Wildlife Interactions*. 9:229–235.
- Stringham, S. F., and A. Bryant. 2016. Distance-dependent effectiveness of diversionary bear bait sites – *Commentary*. *Human-Wildlife Interactions*. 10:128–131.
- Treves, A. 2009. Hunting for large carnivore conservation. *Journal of Applied Ecology*, 46:1350–1356.
- Treves, A., K. J. Kapp, and D. M. MacFarland. 2010. American black bear nuisance complaints and hunter take. *Ursus* 21:30–42.
- USFWS (US Fish and Wildlife Service). 2016. FINAL DRAFT, Draft 2016 Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem.
- Wikipedia 2018a. en.wikipedia.org/wiki/List_of_fatal_bear_attacks_in_North_America.