Effects of Pedestrians on Grizzly Bears

An Evaluation of the Effects of Hikers, Hunters, Photographers, Campers, and Watchers

David J. Mattson, Ph.D.

Report GBRP-2019-3

2019

The Grizzly Bear Recovery Project

P.O. Box 2406, Livingston, Montana

Table of Contents

1. Introduction

Researchers have documented broadly similar patterns in how grizzly and brown bears respond to people on foot throughout the Northern Hemisphere. Yet there is also substantial documented variation that is plausibly attributable to differences in individual bears, human-bear history, bear-bear interactions, distributions and abundances of people, behaviors of involved people, the predictability of human activity, and the distributions of food resources vis-à-vis humans. And variation can also be found in scaling up from responses of individual bears to responses manifest at an aggregate population level.

My goal here is to not only elucidate widespread commonalities, but also contextualize individual and population-level variation revealed in the corpus of research relevant to reactions of brown and grizzly bears to people on foot. My prospectus here pertains only to pedestrians or pedestrian-related infrastructure (e.g., trails and backcountry campsites), not motorized human activities (e.g., highway and ATV-track traffic or motor boats and planes), although the boundary is necessarily fuzzy given that some single-track trails support both foot and motorized traffic.

I use the term "pedestrian" in this report as a more succinct way of referring to foot-bound people. The term is not burdened by the presumed intentions of involved people—e.g., hunter, hiker, backpacker, viewer, walker, researcher, etc.—and instead is more neutrally descriptive. Moreover, my usage is consistent with Merriam-Webster's definition: "going or performed on foot."

Parenthetically, variation in reactions of bears to pedestrians might arise from intrinsic differences between European brown bears and Northern American grizzly bears, which are both of the same species, *Ursus arctos*. Nonetheless, I draw on research from both genetic lineages. The relatively minor differences in behaviors of bears on these two continents are, I will argue, more plausibly rooted in history and environment than genetically-driven predispositions. For convenience, I therefore refer to all *Ursus arctos* as "grizzly bears," but, where relevant, identify the provenance of invoked research.

1.a. Clarification of Terminology

Because results of the phenomenological research on pedestrian impacts that I summarize here are varied, a contextualizing framework is essential for interpretation. Clarity of terminology is also important.

More specifically, I found that my synthesis benefited from deploying terms that emphasized descriptions of observable behaviors rather than the presumed motivations and antecedent experiences of individual bears. Judging cognitive and emotional processes for other humans is problematic enough, much less for animals. Unfortunately, many terms commonly deployed in bear research and management are mired in surmise about neurologic and cognitive phenomenon (e.g., Hopkins et al. 2010), none more so than "habituated" and "conditioned" as descriptors of individual animals (Herrero et al. 2005). Even though valuable for understanding and communicating about why certain behaviors arise in certain bears (e.g., Aumiller & Matt 1994), such terms can obfuscate more than clarify when applied to synthesizing research.

Herrero et al. (2005) contributed to a much-needed conversation about developing a vocabulary that was more overtly descriptive of bear behaviors rather than their presumed motivations, although these authors ended up emphasizing the term Overt Reaction Distance (ORD). Unfortunately, ORD is premised on an inescapable spatial dimension that imposes substantial limits on use especially in application to avoidance of humans by bears at the scale of both individuals and populations.

For my purposes here, I therefore emphasize the terminology of reactivity to generically characterize responses of bears to people; e.g., more reactive versus less reactive. Greater reactivity manifests as greater proclivity to charge, run away, or avoid humans and human features altogether. Less reactivity manifests as more neutral immediate responses, or a greater tendency to use areas nearer people.

But I have also found it useful to invoke habituation and resulting tolerance of humans as an explanation for observed bear behaviors. As Herrero et al. (2005), Smith et al. (2005), and Blumstein (2016) emphasize, tolerance is an outcome, whereas habituation is a process, with tolerance manifesting among individual bears as a consequence of several phenomena, including habituating lifetime experiences, the drive to obtain resources near people, and cultural transmission in the form of learning from other bears, notably mothers. Of relevance as well, Stringham & Rogers (2017) argue that the native state for bears is likely one of ambivalence towards humans, and that fear—or heightened reactivity—arises from histories of persecution, adverse individual experiences, or transference of intolerance of other bears to intolerance of people (see also Smith et al. 2005).

1.b. Transference and Contingency

As a premise, tolerance for other bears is likely to transfer to tolerance for humans, with tolerance for other bears contingent on overall bear densities as well as the extent to which bears are concentrated near each other temporally and spatially by high-quality resources. Logically, the greater the bear densities, the greater the concentrations, and the greater the imperative to access a resource, the more bear-bear interactions there are, with a likely waning of intolerance for other bears as the individually-experienced or culturally transmitted outcomes of habituation.

Likewise, habituation of bears to people is likely to be accelerated under circumstances where there are high densities of benign people, especially when concentrated in predictable places at predictable times (Herrero 2002, Herrero et al. 2005); or even when lower densities of people are similarly concentrated in time and space (Aumiller & Matt 1994). This amplification of tolerance, when coupled with transference, likely yields bears that are unreactive to people, as in coastal areas of Alaska where bear densities are exceptionally high, spawning salmon contribute to concentration, and people are controlled as part of bear-viewing programs.

Smith et al. (2005) offer evidence in support of these propositions. They found that the average distances at which grizzly bears initiated charges at people were negatively correlated with bear densities in Alaska (Fig. 1B). Similarly, as another proxy for high reactivity, they found that numbers of attacks by grizzly bears on people were far more common in areas with the lowest bear densities (Fig. 1A), in defiance of what one might expect from a comparatively low absolute number of encounters between humans and bears in areas where both are scarce.

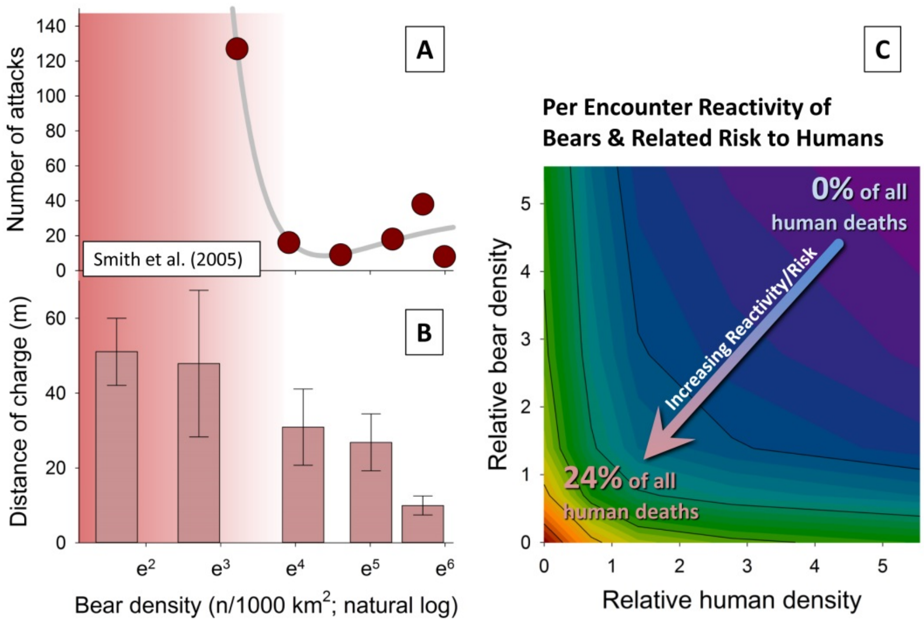


Figure 1. *Relations between numbers of attacks by grizzly bears on people (A) and the distance at which a grizzly bear initiated a charge (B) relative to bear densities in Alaska. (C) portrays a conceptual relationship between grizzly bear and human densities and reactivity of bears involved in encounters with people; the percent of all documented human fatalities caused by grizzly bears is also shown for extremes of reactivity and risk.*

I've synthesized some aspects of how density-related factors synergize to affect individual and population-level reactivity of grizzly bears in Figure 1C. By this reckoning, per encounter reactivity is likely to be lowest in areas where human and bear densities are locally highest. Prime examples are bear viewing areas in coastal areas of Alaska, such as at Brooks and McNeil Rivers, where large numbers of bears are concentrated at high-quality spatially-restricted resources, together with comparatively high local densities of humans who are closely regulated and restricted to spatially-confined areas (Fig 2A). Encounters are spatially and temporally predictable, routinely benign, resulting in remarkably few human injuries—which almost certainly reinforces tolerance and lowers reactivity (Aumiller & Matt 1994, Herrero et al. 2005).

At the other extreme, per encounter reactivity is likely to be highest were grizzly bear densities are lowest and encounters with humans and other bears comparatively uncommon. Even where people are spatially confined to trails or streams, encounters under such circumstances are still likely to be registered by the involved bears as unpredictable and hazardous. Prime examples can be found in the high-latitude Arctic and boreal regions of Alaska and Canada (cf., Miller et al. 1997, Mowat et al. 2013; Fig. 2B). These regions correspondingly account for over 23% of all documented human fatalities caused by grizzly bears (https://en.wikipedia.org/wiki/List_of_fatal_bear_attacks_in_North_America) under circumstances where, again, there have probably been comparatively few encounters between people and bears.

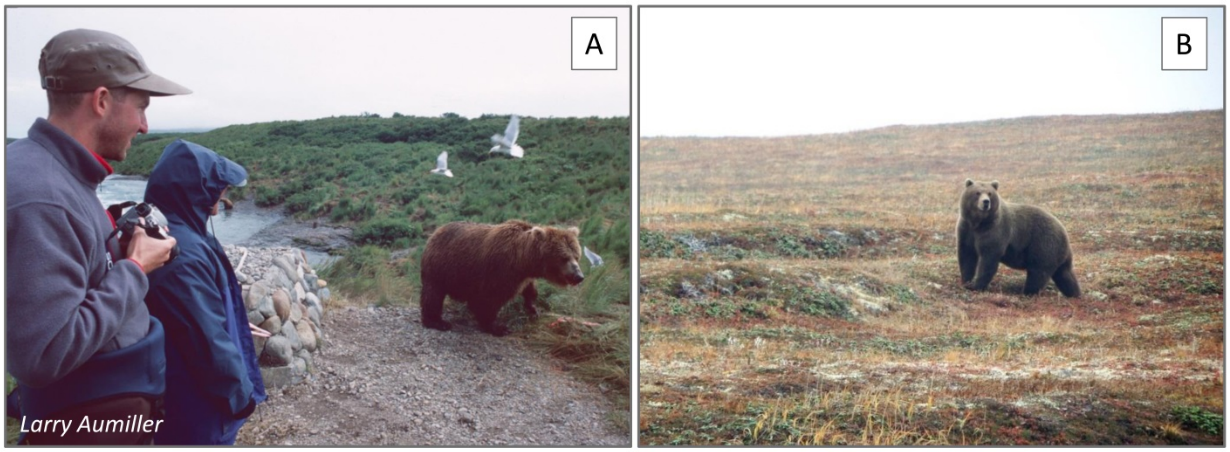


Figure 2. *(A) A tolerant grizzly bear eating salmon within a few yards of people on a viewing platform at McNeil River, and (B) a vigilant grizzly bear on the tundra of Alaska.*

This relatively straight-forward framework relating reactivity and risk to human and grizzly bear densities is central to interpreting differences in research results, especially from studies that focus on human-bear interactions along coastal rivers and streams in Alaska and Canada versus studies in interior regions where bear densities are lower and food resources more dispersed. This framework also specifies contingencies that are critical to judging whether research from coastal regions is applicable to areas with low bear densities—which is often not the case.

2. Organization of the Summary and Synthesis

In what follows I summarize and interpret results from research on reactions of grizzly bears to pedestrians according to a logical hierarchy. I start first with reactions of individual bears to encounters, including how they react, from what distance, and with what immediate and longer-term effects—if any. I follow with a less than exhaustive summary of factors affecting risk for people involved in encounters and then conclude with a review of how bears, in aggregate, disport themselves relative to landscapes and landscape features used by pedestrians—i.e., trails, campsites, and areas of dispersed recreation.

Throughout I present graphics adapted from individual publications that illustrate seminal results, together with other graphics summarizing results aggregated across relevant studies. In instances where I adapted graphics, I prominently credit the originating publication(s). Where appropriate, I offer on-going interpretation that augments and supports my concluding summary and synthesis.

3. Responses of Bears to Encounters with Pedestrians

Grizzly bears overtly react to encounters with pedestrians by running away, remaining neutral, approaching, or charging, with differences between initial and subsequent reactions, and all dependent on how close the encounter is, characteristics and behaviors of the involved humans, and the baseline tolerance as well as age and reproductive status of the involved bear. All of this has ramifications for the bear as well as for human safety.

A bit less dramatically, pedestrians can also displace grizzly bears or disrupt their activities, evident in negative spatial and temporal correlations between pedestrian and bear activity, as well as effects on foraging efficiencies of bears. Given the generally lower reactivity of grizzly bears along spawning streams, responses to pedestrians here are more often manifest in these somewhat more subtle forms compared to outright flight or charges.

In what follows, I decompose encounters and patterns of association and disassociation into behavioral facets that have been quantified by various researchers, but with reference to human- and bear-related factors that have been implicated in configuring outcomes.

3.a. Probability of Flight

Probability of flight is merely one behavior among several typifying reactions of grizzly bears to encounters with pedestrians, and yet, along with likelihood of charging, perhaps the most indicative of how reactive they are to people. Averaged over the 15 studies for which flight was reported, plus an additional five strata within, grizzly bears ran away from an encounter 72% (1 SD = 22) of the time (Chester 1980; Gunther 1990; Haroldson & Mattson 1985; Jope 1985; Jope & Shelby 1984; Linden 2018; McArthur-Jope 1983; McLellan & Shackleton 1989; Moen et al. 2012, 2019; Naves et al. 2001; Ordiz et al. 2019; Revenko 1994; Sahlén et al. 2015; Schleyer et al. 1984) . Given that some have theorized that flight may be more likely among hunted compared to protected grizzly bears, I also calculated average probability of flight by this distinction (Fig. 3A). Although flight was somewhat more likely among hunted compared to protected bears (by a difference of 13%), the variability among studies was large enough to debar any confident conclusions, as was the confounding of this distinction with results from Europe versus North America.

Apart from these broad generalities, there were differences among bears that could be attributed to levels of tolerance and broader conditioning factors. Bears that were judged to be “habituated” were less likely to flee (Herrero 2002)—on only around 20% of occasions upon encountering pedestrians in the open habitats of Pelican Valley in Yellowstone National Park (Gunther 1990). Similarly, grizzly bears that more commonly used areas heavily used by people were less likely to move away compared to those that avoided these environs (Jope 1985; Fig. 4)), among which were tolerant adolescents that fled on only 30% of occasions (Jope 1983; Fig. 5). By contrast females with cubs-of-the-year (COY; Fig. 5), bears encountering pedestrians in open areas, and bears encountering people at shorter distances (<150 m, Fig. 6), more commonly fled, moved away, or were otherwise more reactive compared to bears without COY, in cover, or at farther distances (Haroldson & Mattson 1985, Jope 1983, Linden 2018, McLellan & Shackleton 1989, Moen et al. 2012, Sahlén et al. 2015, Schleyer et al. 1984).

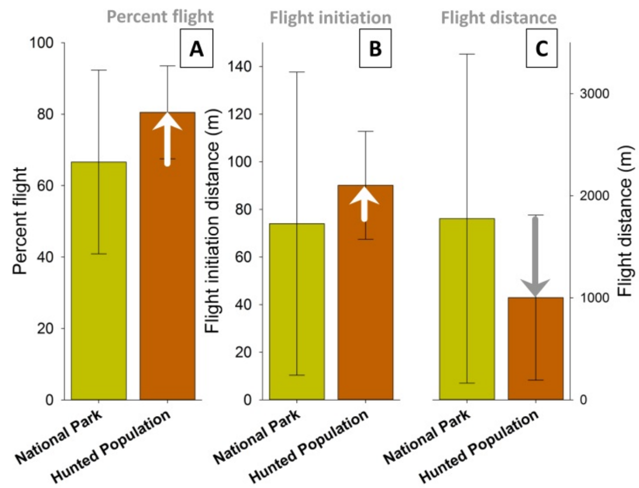


Figure 3. *Summary of reactions by grizzly bears to encounters with people, averaged across all studies for which data are given, including (A) probability of flight, (B) distance at which flight was initiated, and (C) subsequent distance of rapid movement.*

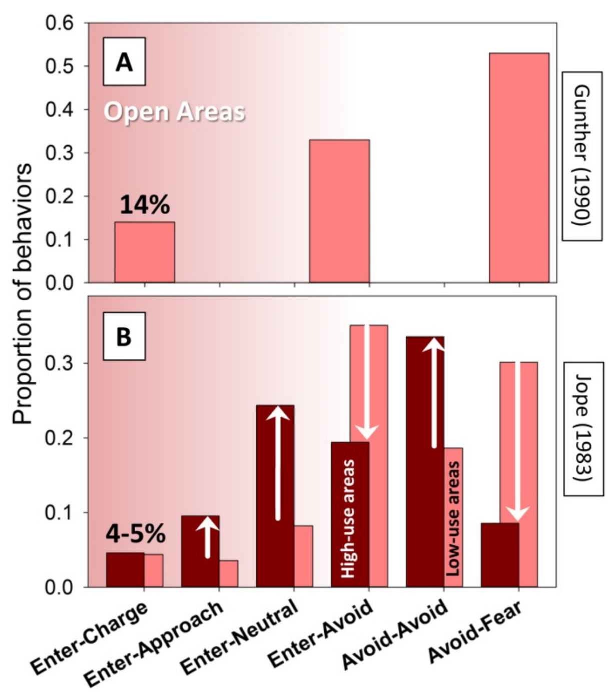


Figure 4. *Probability that grizzly bears would display different behaviors (A) upon encountering pedestrians in open areas, and (B) as a function of whether they routinely used areas more or less heavily used by humans in Glacier National Park (e.g., < versus > 1.5 hiker/hour on trails).*

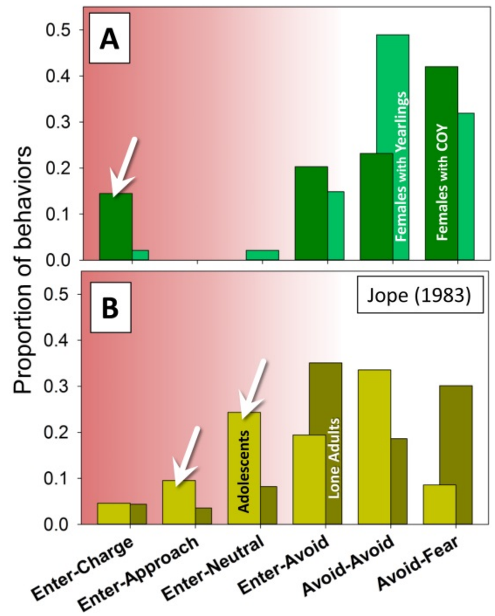


Figure 5. *Reactions of different sex-, age-, and reproductive classes of grizzly bears to pedestrians in Glacier National Park, differentiating (A) females with COY; females with yearlings; (B) adolescents; and lone adult bears.*

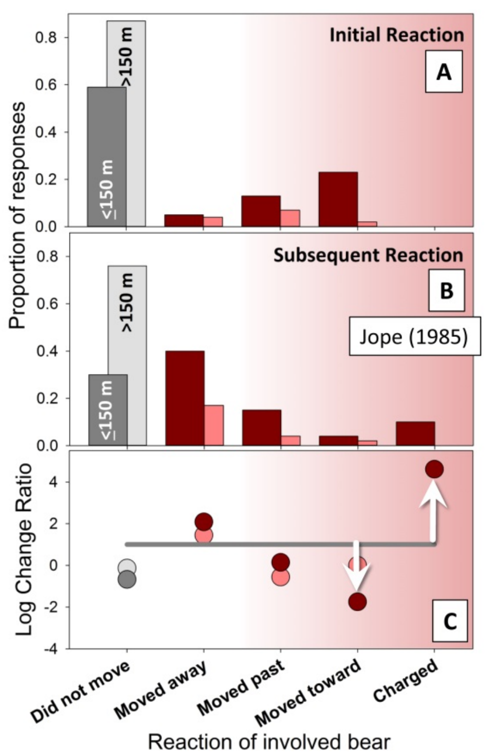


Figure 6. *Reactions of grizzly bears to pedestrians in Glacier National Park, (A) initially and (B) subsequently, as a function the distance at which the encounter occurred (≤150 m v >150 m). The change between initial and subsequent reactions is shown as a ratio in (C), differentiated by encounter distance.*

3.b. Distance of Encounter and Initiation of Flight

The distances at which human-grizzly bear encounters occurred are also indicative of reactivity, but potentially contaminated with even more bias than observations regarding the probability that involved bears would flee. In studies based exclusively on visual observations by people (e.g., all the research conducted in Glacier National Park; McArthur-Jope 1983, Jope & Shelby 1984, Jope 1985, Nadeau 1987), the documented distances of encounters and reactions of bears are obviously contingent on the animals having been seen, which for radio-marked bears in forested regions of Scandinavia amounted to between only 15 and 24% of encounters (Moen et al. 2012, Ordiz et al. 2013, Sahlén et al. 2015). However, the results I summarize here regarding encounter distances are based almost exclusively on studies with radio-marked bears (Haroldson & Mattson 1985, Moen et al. 2019, Naves et al. 2001, Schleyer et al. 1984) or observations of bears in open areas (Gunther 1990).

Averaged across studies, grizzly bears encountered pedestrians at around 85 m (± 34 m), with that distance somewhat greater for bears in hunted populations (90 m) versus protected populations (74 m). Even so, this ostensible difference was well within the observed variability surrounding each estimate (Fig. 3B). In Glacier National Park, observed encounters were nearly 14-times more likely to occur under circumstances where visibility was <30 m or where near (<20 m from) running water, which was a commonplace occurrence in wet habitats with thick vegetation cover (Nadeau 1987). Otherwise, not surprisingly, bears that were active tended to be encountered at greater distances compared to bears encountered while bedded (i.e., “passive”; Haroldson & Mattson 1985, Moen et al. 2012). Bedded bears tend to be less visible and therefore likely to be encountered at closer ranges partly because they are more often sequestered in thicker vegetation (Mysterud 1983, Skuban et al. 2018).

3.c. Flight Distances

As with encounter distances, almost all results pertaining to distances of subsequent flight or other rapid movements away from people were obtained from radio-marked bears, which minimized observational bias (Haroldson & Mattson 1985, Moen et al. 2019, Naves et al. 2001, Schleyer et al. 1984). The one exception is results from Gunther (1990) of bears in open areas, which truncated his estimates of flight when bears moved into nearby forested habitats.

Flight distances averaged across studies were near 2 km (1740 ± 1317 m), with minimal basis for any conclusions regarding differences between hunted and protected populations given the substantial observed variability (Fig. 3C). Aside from these broad generalities, flight distances were greater for females with COY compared to other bears (Sahlén et al. 2015; Fig. 7); for bear encountered while active as opposed to bedded (Haroldson & Mattson 1985, Sahlén et al. 2015; Fig. 7); and in areas less intensively used by people (McLellan & Shackleton 1989)—none of which is surprising. Females with COY are known to be more reactive in defense of vulnerable offspring (Herrero 2002), whereas greater reactivity among bears less often exposed to people is consistent with the framework I describe in 1.b.

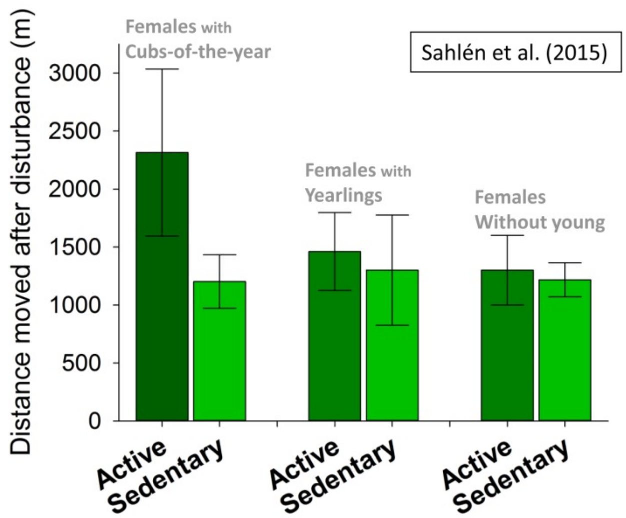


Figure 7. *Effects of reproductive status and level of activity at time of an encounter with pedestrians on subsequent distance moved by adult female bears in Scandinavia.*

3.d. Longer-Duration Effects

With the exception of highly tolerant individuals, reactions of grizzly bears to encounters with pedestrians were often evident for 24-72 hours, although sometimes obscured by or confounded with natural variation associated with fine-scale shifts in diets and foraging strategies (Haroldson & Mattson 1985). Most notably, above and beyond initial reactions, movements generally increased, especially for females with COY, as did overall levels of activity—by as much as 1.5-fold (Schleyer et al. 1984, Sahlén et al. 2015). Bears also often reacted by becoming more nocturnal—for as long as 3 days afterward (Ordiz et al. 2013, 2019; Fig. 8). As a corollary, involved bears tended to select for areas with greater cover, manifest as substantial reductions in use of open areas (e.g., 4-fold less use; Gunther 1990, Schleyer et al. 1984), as well as movement to habitats with lower line-of-sight visibility, especially when the initial encounter had occurred in a more open setting (Sahlén et al. 2015; Fig. 9). Overall, the pattern was one for affected bears to reduce the likelihood of further encounters with humans by selecting for times of day and habitats when and where people would be less active. And, as expected, the longer-term impacts were greatest on females with COY.

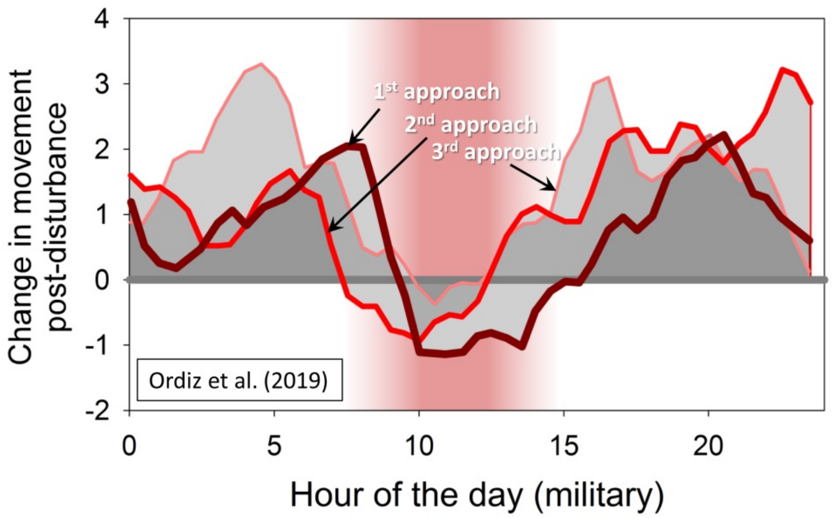


Figure 8. *Changes in levels of diel activity relative to pre-encounter baselines for Scandinavian brown bears approached by researchers on 3 successive occasions. Daytime activity declined whereas nocturnal activity increased, without much waning of impacts even after the third approach.*

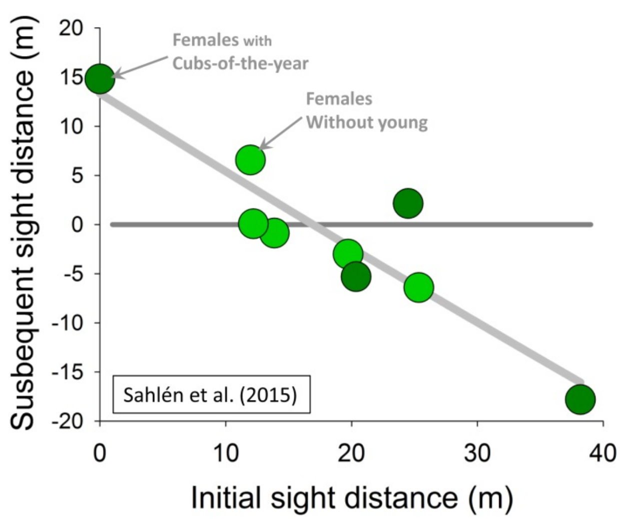


Figure 9. *Changes in amount of vertical cover (i.e., line-of-sight distance) between sites at which encounters occurred and sites to which bears moved for females with and without COY. The greater the cover at encounter sites, the less the subsequent compensation.*

4. Risk Factors for Pedestrians during Encounters

The extent to which reactions by grizzly bears to encounters with pedestrians translate into aggression—or even physical harm—is of obvious relevance to managers and the involved people. It is perhaps self-evident that heightened fear likely manifests in greater reactivity by a bear, and that accentuated reactivity includes both flight and overt aggression (Herrero 2002). Short-range surprise logically amplifies perceived threat for involved bears, as does, notoriously, perceived threat to attendant cubs. This is not to say that aggression arises solely from perceptions of threat. The other well-documented circumstance under which bears aggressively approach pedestrians is when natural or anthropogenic foods –or even space—are being contested (Herrero 2002). Nonetheless, during chance encounters injury is usually preceded by a charge.

4.a. Likelihood of Being Charged

The odds of a pedestrian being charged during an encounter with a grizzly bear are small, even under broader-scale conditions where bears are likely to be more reactive (e.g., Fig. 1). Actual estimates of these odds are necessarily contingent on fulfilling the difficult task of obtaining data on overall numbers of human-bear encounters, although several studies have done so. Even with such data in hand, problems axiomatically arise in defining exactly when an encounter has occurred and, even more vagarious, what aggression looks like. All of these phenomena defy definitional closure, as emphasized by my own experiences where a "charge" (by some people's standards) encompassed, at one extreme, rapid movement towards me motivated by what appeared to be curiosity or confusion to, at the other extreme, apparent deadly intent. Even so, some generalizable conclusions are possible.

In more open habitats with lower grizzly bear population densities typical of interior North America, 6.1% (SD = 1.4%) of 279 documented encounters resulted in overt aggression by the involved bear (Chester 1980, Schleyer et al. 1984, Haroldson & Mattson 1985, McLellan & Shackleton 1989, Gunther 1990, Leonard et al. 1990), although much of this result was driven by a single study area where food-conditioned bears were implicated (Leonard et al. 1990). Without this study, the percent of encounters typified by aggression dropped to 4.5% (± 2.2).

In Glacier National Park a somewhat higher 7-9% of all documented encounters resulted in "a charge" (Jope & Shelby 1984, Jope 1985, Nadeau 1987), typically in thicker vegetation where short-range (<30-50 m) surprise encounters were more likely to occur (Nadeau 1987). Even so, this percent was predictably inflated by the fact that encounters were reckoned only to the extent that the involved people were aware of them, which excluded encounters where the bear left with people unawares. If included, these encounters would certainly lower the percentage for Glacier Park, probably to within the range of results from other study areas.

Otherwise, odds of overtly aggressive responses by bears were essentially nil, notably in Scandinavia (Moen et al. 2012, 2019; Ordiz et al. 2013, 2019; Sahlén et al. 2015), and so small as to not warrant direct study in most coastal areas of North America where pedestrians were concentrated in specific locales. In fact, Aumiller & Matt (1998) reported only 8 "intense charges" during 21 years of close interactions with grizzly bears concentrated at McNeil River Falls in Alaska, consistent with the broader patterns documented by Smith et al. (2005; Fig. 1). As an exception proving the rule, Revenko (1994) documented aggression during 4% of encounters with grizzly bears in coastal areas of Kamchatka, but under conditions where human activity was quite low and bears probably not used to encountering pedestrians under any circumstances.

4.b. Factors Influencing Likelihood of Being Charged

Even given the generally low odds that grizzly bears will be aggressive towards pedestrians, some circumstances predictably escalate encounters. Most unambiguously, females accompanied by cubs-of-the-year (COY) are more likely to charge during an encounter compared to any other type of bear. In fact, McArthur-Jope (1983) found that females with COY were 4-7-times more likely to react in what appeared to be an aggressive manner (Fig. 5A). DeChano & Butler (2002) similarly found that females accompanied by young accounted for a disproportionate 31% of charges on trails in Glacier National Park. Likewise, even though grizzly bears were overall no more likely to charge when encountered in areas heavily used by pedestrians (Fig. 4B), the full charges that did occur were almost exclusively by females with COY (Jope & Shelby 1984).

In case of females with COY, a major motivation for aggression is obviously protection of young. But there are additional situational factors that predictably increase the odds that grizzly bears will react aggressively to an encounter. First and foremost is if they are surprised—or startled—at close quarters (<50-150 m; Jope 1985, Nadeau 1987, Herrero & Higgins 1999), which is more likely to occur in thick vegetation or where running water creates ambient noise (Nadeau 1987, Smith & Herrero 2018). Again, whether a bear is "surprised" is prey to human interpretation, but surprise is a universal enough experience that most people can probably make a reliable determination. Relatedly, bears are seemingly more likely to be startled if people are moving quietly, which is plausibly less likely to occur if they are in groups (e.g., 2-3 or more people [Gunther 1990, Smith & Herrero 2018], although Kendell [1983] and Jope [1985] found no such effect) or even carrying noise-makers such as bells. In fact, grizzly bears in Glacier National Park did not charge pedestrians on any occasion when the involved people were known to be carrying bells, in contrast to on 14% of occasions when people were not (Jope & Shelby 1984).

Whether or not bears are used to encountering pedestrians in certain areas at certain times of day also plausibly affects levels of "surprise" or whether involved bears register an encounter as more threatening simply because the context is more uncertain. Aside from general propositions (Section 1), the best evidence for this effect again comes from Glacier National Park. Pedestrians on low-use trails were far more likely to be charged by grizzly bears during an encounter compared to pedestrians in areas more heavily used by people—by factors of 2-fold or more (Jope & Shelby 1984, Jope 1985, Nadeau 1987). All of this is consistent with results of Smith et al. (2005) showing that grizzly bears in low-density bear populations were likely to charge pedestrians at roughly 5-times greater distances compared to bears in high-density coastal populations (Fig. 1B).

4.c. Likelihood of Being Injured

It probably goes without saying that people who are on foot are far more likely to be injured by a grizzly bear compared to people in vehicles or hard-sided lodgings—who are not altogether immune (Herrero 2002). For example, in Scandinavia, British Columbia, and Alberta pedestrians accounted for 59% to 100% of all people injured by grizzly bears (Herrero & Higgins 1999, 2003; Støen et al. 2018). The remainder of victims is largely accounted for by people in tents or on foot around a campsite or cabin, which is not my focus here given that most of these incidents involved anthropogenic attractants.

Leaving aside the perhaps obvious fact that pedestrians are more vulnerable to injury compared to people sequestered in hard-sided shelters, the odds that a pedestrian will be mauled during an encounter with a free-ranging grizzly bear are so small as to defy calculation. For example, in Scandinavia where researchers directly approached grizzly bears on literally hundreds of occasions, overt aggression was never documented, much less an attack (Moen et al. 2012, 2019; Ordiz et al. 2013, 2019; Sahlén et al. 2015). The same holds true for coastal study areas in North America centered on areas of concentrated pedestrian activity along or near salmon spawning streams (e.g., Aumiller & Matt 1998).

The best estimates for odds of injury during an encounter with a grizzly bear in interior regions of North America come from Glacier National Park (Nadeau 1987) and by amalgamating results from multiple studies elsewhere (Chester 1980, Schleyer et al. 1984, Haroldson & Mattson 1985, McLellan & Shackleton 1989, Gunther 1990, Leonard et al. 1990). In the first case, only 6 of 1000 encounters resulted in human injury; in the second, only 3 in 1000 did. Gunther (2015) estimated an even lower 1 in

200,000 chance of injury for backcountry campers in Yellowstone National Park, but reckoned against total number of registered overnight users rather than on a per encounter basis.

Even so, managers and backcountry users are interested in knowing the odds that *aggressive reactions* by grizzly bears will result in human injury, realizing that odds of an aggressive reaction are small in the first place. With that proviso, roughly 6-8% of aggressions resulted in injury to a pedestrian in interior regions of North America outside of Glacier National Park (Chester 1980, Schleyer et al. 1984, Haroldson & Mattson 1985, McLellan & Shackleton 1989, Gunther 1990, Leonard et al. 1990, Bertch & Gibeau 2009). In Glacier Park that figure was around 6-14%, depending on how aggression was defined by investigators (Kendall 1983, Nadeau 1987).

Leaving aside generalized rates, there are again certain factors that amplify risk of human injury during an encounter with a grizzly bear, most of which mirror factors amplifying risk of aggressive reaction, but with the proviso that much of the relevant information is based on tallies rather than rates. This last qualifier arises from the simple fact that data suitable for calculating rates are rarely available once risk is decomposed into underlying processes.

As Herrero (2002) identified more than 30 year ago, encountering a female with COY is clearly a major risk factor for pedestrians. A disproportionately large number of maulings have been attributed to females with young in Scandinavia (61%, Stoen et al. 2018), Alberta (59%, Herrero & Higgins 2003), Glacier National Park (33%, DeChano & Butler 2003), and Alaska (26%, Smith & Herrero 2018). Nadeau (1987) similarly found that confrontations with family groups were 1.3 to 1.6-times more likely to result in human injury compared to confrontations with lone adults or adolescents, but with this estimate confounded by variation in how investigators in Glacier National Park have defined a "confrontation" versus a "close confrontation" versus an "aggression."

Otherwise, as with aggressive reactions in general, encountering a grizzly bear in areas used less intensively by pedestrians is more hazardous for involved people, presumably because unpredictable events are more likely registered by bears as a threat. For example, given a confrontation, injuries were nearly 10-times more likely off-trail and 4-times more likely on low-use trail compared to on high-use trails in Glacier National Park (Nadeau 1987). The percentage of injuries from close confrontations was similarly estimated to have been as high as 40-50% in the backcountry and on low-use trails compared to 10% on high-use trails (Nadeau 1987). Related to the factor of "surprise," maulings in North America have overall been more common in areas of poor visibility (Herrero & Higgins 1999, Smith & Herrero 2018) or where pedestrians were traveling as singletons or duos (Herrero & Higgins 1999).

4.d. The Hazards of Hunting

Hunting on foot for big game such as moose (*Alces alces*) or elk (*Cervus canadensis*) in areas occupied by grizzly bears seems to be remarkably hazardous for the involved people. There are no data from which risks can be explicitly calculated (for example, odds of being charged or injured as a function of exposure), but all of the available evidence points to elevated hazards relative to most other pedestrian activities.

Some evidence comes from simple tallies of humans killed by grizzly bears. For example, of the 72 people who were killed in North America since the mid-1950s, 21% were hunting big game—a number that almost certainly far exceeds the proportion of hunters relative to other pedestrians active in areas occupied by grizzly bears. Of the seven fatalities where relevant information is readily available, six involved the presence of an animal recently killed by a hunter—in other words, an attractant. Looking at all recorded human fatalities going back to the early 1800s, an additional eight were attributable to people who were actively hunting grizzly bears, including five who were hunting over some sort of bait. When these fatalities are included, roughly 29% of the total involved hunters.

A handful of studies provide information regarding circumstances under which pedestrians have been injured that is also relevant to judging the hazards of hunting. Again, hunters account for what is almost certainly a disproportionately large number of the injured—25% of the total in British Columbia (Higgins et al. 1999); 59% of the total in Alberta (Herrero & Higgins 2003); and 75% of the total in Scandinavia (Støen et al. 2018). Of the last, 79% had shot at or wounded a grizzly bear, consistent with the raw number of fatalities involving bear hunters in the contiguous United States prior to widespread extirpations of grizzly bears. Of additional relevance, 20% of all incidents where people were injured by grizzly bears in British Columbia involved bears either defending or attempting to appropriate an animal carcass—again, often involving hunters (Herrero & Higgins 1999).

The disproportionate numbers of hunters among those injured or killed by grizzly bears is not surprising. By first principles, hunters behave in ways that magnify rather than diminish risks. They are often moving stealthily, which increases odds that bears will be surprised during an encounter (see 4.b. and 4.c.). They are also typically active in areas where bears plausibly associate people with the availability of food in the form of hunter-killed carcasses (e.g., Haroldson et al. 2004; Section 6.d.). Moreover, hunters are often closely associated either in the field or in camp with the remains of animals they have killed. Under such circumstances, bears are likely to be actively searching for hunter-associated kills in hunter-frequented areas with the intent of appropriating available edibles. Involvement of attractants under such circumstances unambiguously increases the odds that grizzly bears will aggressively contest food and space (Herrero 2002).

Given these data, it is remarkable that there have been no explicit studies of factors configuring risks for hunters. The closest approximation is in several white papers produced by managers in the Yellowstone Ecosystem who were tasked with developing recommendations for reducing levels of conflict between bears and people, including hunters (Toman et al. 1991; Servheen et al. 2004, 2009). The results either directly identified—or tacitly implicated—risk factors for hunters, including hunting alone; archery hunting, especially when done with an audio aid designed to attract bulls; contesting carcasses claimed by bears; leaving carcasses out overnight; and otherwise "improperly handling" carcasses. All of these factors relate to either increased odds that bears would be startled or encountered under circumstances where food was contested. Either way, aggression by bears would be likely.

5. Displacement

As I use it here, "displacement" denotes coarser-grained spatial and temporal reactions of grizzly bears to increased levels of human activity. Displacement is a phenomenon that transcends the resolution of individual encounters, yet is subsumed within less dynamic population-level patterns. By definition, displacement is manifest in statistical summaries that incorporate the responses of multiple animals, not the reaction of an individual bear to an individual encounter, which has been my focus so far. Even so, I differentiate displacement from avoidance. I treat "avoidance" as a phenomenon that manifests in population-level data, especially in relation to geospatially static features such as trails and backcountry campsites. Displacement and avoidance are not unambiguously distinct, but rather mid- and higher-order partitions of a hierarchical continuum of both data and ecological and behavioral processes.

The finer-grained and comparatively more immediate behavioral nature of displacement versus avoidance makes displacement more easily documented in—as well as more relevant to—areas with higher densities of both bears and people. Because of this, most of the research pertaining to displacement comes from observational and intensive telemetry studies of grizzly bears along coastal streams in Alaska and British Columbia, whereas most of the results pertaining to avoidance come from radio-telemetered bears tracked with varying degrees of resolution in interior regions. Moreover, higher densities of bears and people in coastal study areas have allowed for *de facto* or deliberate designs that allow comparison of bear behaviors during periods (or in areas) with versus without human activity.

5.a. Spatial and Diel Displacement

Figure 10 summarizes the results of before-after and control-treatment studies of reactions by coastal grizzly bears to the presence of humans (e.g., Olson et al. 1994, 1997; Pitts 2001; Crupi 2003; Smith

2002; Van Dyke 2003; Smith & Johnson 2004; French 2007; Rode et al. 2006a, 2007; Marshall 2008). In each instance, humans were either absent or relatively scarce in contrast to being present in substantial numbers. The results of these coastal studies were measured in diverse ways, including numbers of bear present, levels of bear activity, proportions of bear behavior, and ingestions of nutrients and energy. I standardized these various measures to a common scale amenable to comparison across studies. I also grouped results according to whether they applied to all bears without distinction, female bears only, or animals that were more rather than less evidently tolerant to humans (e.g., habituated versus not habituated).

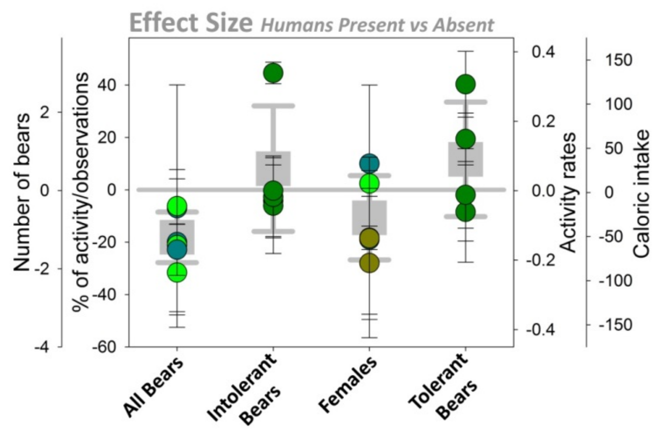


Figure 10. *Mean and standard deviation (in gray) of differences in reactions of coastal grizzly bears (i.e., effect sizes), to the presence versus absence of substantial numbers of people, differentiated by whether results applied to all bears, female bears, or bears evidently intolerant versus tolerant of people. Each dot and bracketing uncertainty interval pertains to a specific study; each color pertains to a different standardized measure reckoned against vertical scales to the left and right.*

These studies of contrasts yielded variable results. In instances where reactions of all grizzly bear were pooled, the presence of substantial numbers of people unambiguously resulted on average in a negative impact on bears, however measured. Effects parsed out for females and intolerant bears were more ambiguous. At the other extreme, bears judged to be tolerant of humans were relatively unaffected—or even plausibly benefited by—the presence of substantial numbers of people. Of relevance to extrapolation, these results are qualified by being in context of high densities of bears within which there was a dominance hierarchy typified by adult males at the top, lone bears somewhere in the middle, and adolescent males towards the bottom; with females accompanied by young functionally disadvantaged by self-evident concern about the safety of their offspring (Stonorov & Stokes 1972, Egbert & Stokes 1976, Mattson 1990, Ben-David et al. 2004, Gende & Quinn 2004, Suring et al. 2006, Gill & Hellfield 2012). Under such circumstances, smaller tolerant bears and females with young likely benefited from human activity that displaced otherwise dominant and potentially hazardous adults—especially adult males (MacHutchon et al. 1998; Fischbach & Reynolds 2005; Nevins & Gilbert 2005a, 2005b; Rode et al. 2006b).

In addition to spatially and temporally coarse-grained contrasts framed in terms of whether people were or were not present, displacement has also been shown to cause diel shifts in bear activity. Figure 11 summarizes the results of several relevant studies, featuring, again, contrasts framed in terms of the presence or absence of people, but in this instance manifest as changes in aggregate levels of bear activity by time of day—notably in panels A, B, E, and F.

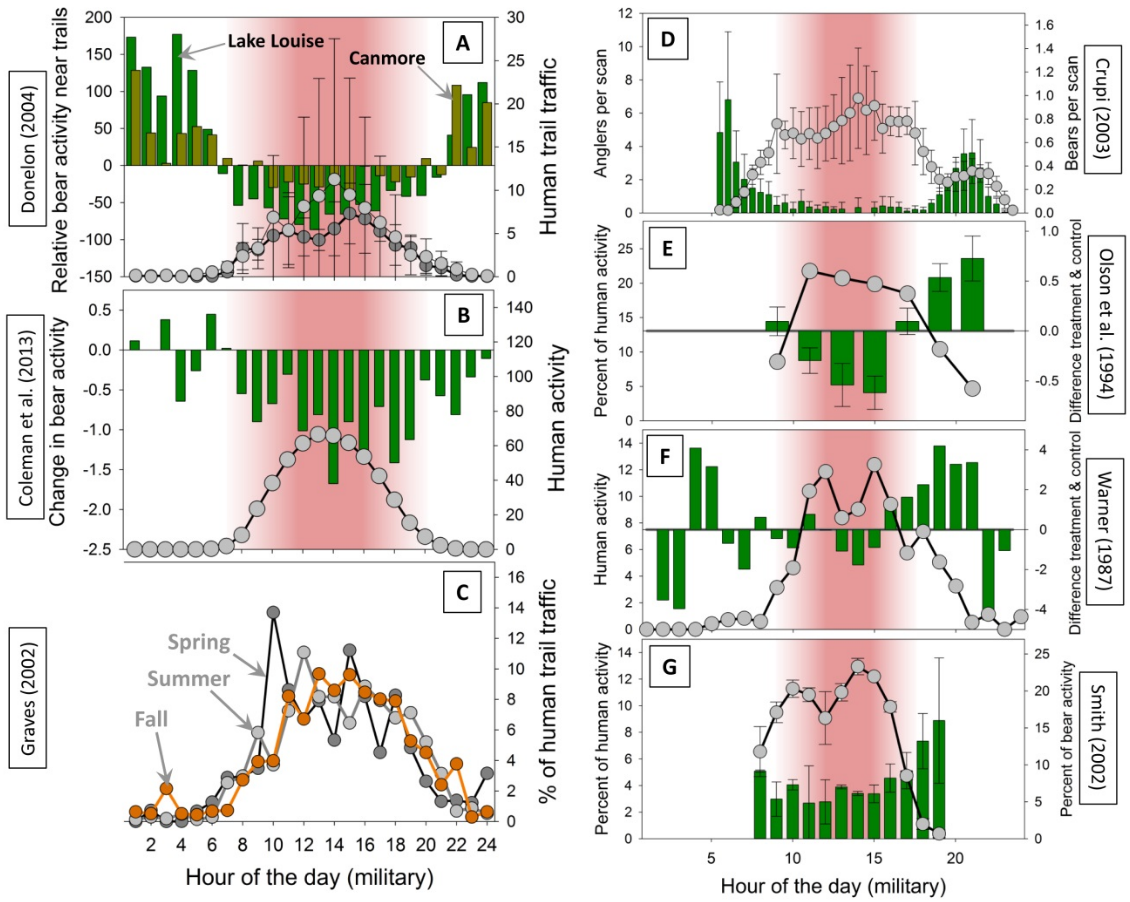


Figure 11. *Relations between diel patterns of grizzly bear (green bars) and pedestrian (gray dots) activity. Results for grizzly bear activity in (A), (B), (E), and (F) are presented as differences between patterns during pre- and post-exposure to substantial numbers of people, with levels of human activity shown only for exposure periods. Results in (D) and (G) are not based on contrasts, but rather show proportional diel distributions of contemporaneous human and bear activity. Levels of human activity on a trail system in the northern US Rocky Mountains during spring, summer, and fall (C) were stationary among seasons. Results in (A)-(C) are from studies conducted in interior regions, whereas results in (D)-(G) are from coastal study areas.*

In every case, grizzly bears became more night active and less day active with the introduction of greater pedestrian traffic (see also Nadeau 1987, MacHutchon et al. 1998). This held both for coastal study areas with high densities of grizzly bears (E & F), as well as for interior regions with lower densities of bears and both fewer (B) and more numerous (A) people. One proviso is warranted regarding the study from Yellowstone National Park where levels of daytime activity dropped most dramatically (Fig. 11B). Part of this diel shift could have been caused by a natural gravitation of bear activity to crepuscular hours with progression of summer (Schleyer 1983, Harting 1985), which coincided with opening of focal areas to pedestrian traffic.

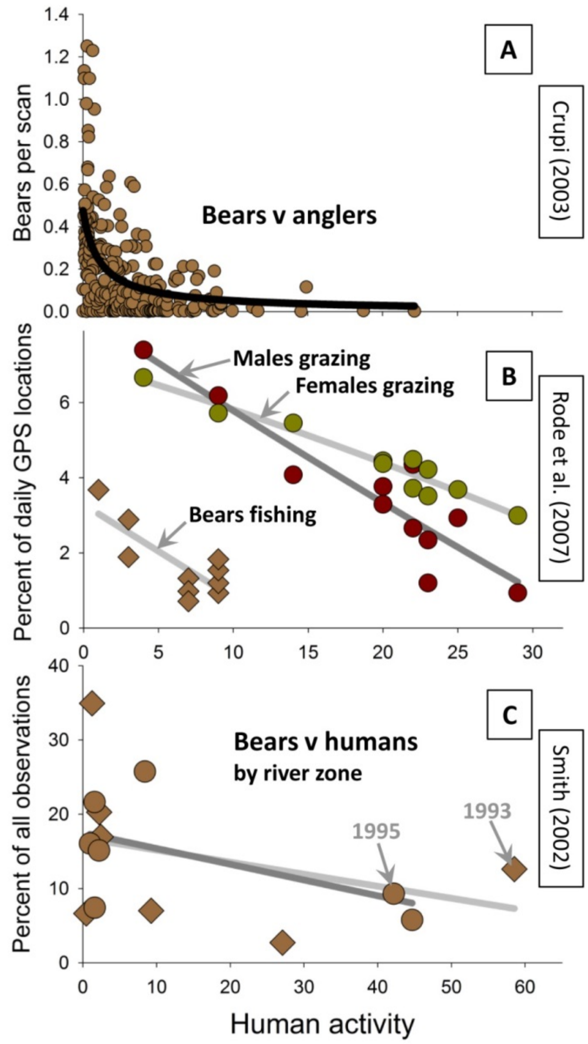


Figure 12. *Relation between aggregate levels of bears and human activity in coastal study areas of Alaska. Results in (A) and (B) were based on temporal differences whereas as those in (C) were based on spatial differences. Trend lines in (B) denote reactions for males (burgundy dots) versus females (green dots), and for bears engaged in different feeding activity (grazing versus fishing). The diamonds and circles in (C) denote data obtained from two different years (1993 and 1995).*

In addition to results based on stark contrasts in numbers of pedestrians using areas occupied by grizzly bears, additional research has revealed more graduated population-level responses of grizzly bears to more graduated increases in pedestrian activity (Fig. 12A and 12B). Although these results are confined to coastal study areas, they show responses that are consistent with results obtained from research in both interior and coastal regions that contrasted periods or areas with and without people. Aggregate levels of grizzly bear activity declined as human activity increased, regardless of the activities or diets of involved bears. In the study by Crupi (2003) the aggregate reaction of bears to anglers was dramatic (Fig. 12A).

5.b. Effects on Foraging Efficiencies

Regardless of whether grizzly bears are physically displaced by people or not, effects of disturbance can manifest physiologically as well as in the behaviors of bears that choose to remain in areas where pedestrians are active. Unfortunately, the very few field investigations of physiological responses to humans have so far been restricted to areas impacted by motorized activity (e.g., Bourbonnais et al. 2013,), which cautions against extrapolation to impacts of pedestrians. Comparatively more research has focused on aggregate changes in behaviors of bears exposed to increased levels of human activity, but almost wholly in areas typified by the greater visibility needed to collect requisite data—notably, coastal Alaska (Pitts 2001; Smith 2002; Crupi 2003; Rode et al. 2006a, 2007; French 2007, Marshall 2008) as well as one study in alpine areas of Glacier National Park (White et al. 1999)—which cautions against unqualified extrapolation to areas with more visual cover. Even so, the available research supports some generalizable conclusions.

Here, again, there is a distinction between research based on before and after or control and treatment contrasts versus other research based on graduated responses in time or space. Figure 13 shows changes in either caloric intake or directly relevant feeding behaviors for three studies that contrasted periods with and without humans present. Although Rode et al. (2006a) argue that changes in mean energy intake with exposure to pedestrians were not each statistically significant, the consistent observed decline (Fig. 13A and 13B) matched similar consistent declines in foraging or fishing activities in her study as well others (Pitts 2001, Crupi 2003). Averaged over 6 studies where changes in foraging efficiencies were in some way measured, the presence of pedestrians resulted in a 29% (± 17%) decline.

A notable exception to this pattern pertains to females with COY using areas subject to controlled viewing of a level sufficient to displace adult male. Nevin & Gilbert (2005a, 2005b) estimated that energy intake of females with COY *increased* by around 66% when adult males were displaced, most likely as a result of controlled pedestrian viewing. This three-way interaction of humans, females with COY, and potentially infanticidal adult males not only yielded prospective foraging benefits for females, but also adolescent bears willing to tolerate humans as means of escaping predation risk from other bears (Herrero et al. 2005), but, notably, under circumstances with high densities of bears and spatially and temporally circumscribed human activity.

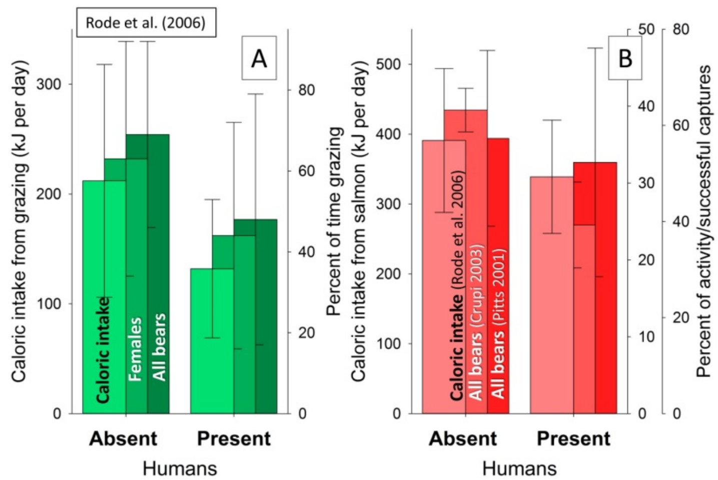


Figure 13. *Measures of caloric intake or foraging activity and efficiencies during periods with and without pedestrians present, including grazing-related measures in (A) and measures related to consumption of spawning salmon in (B). All of these results were obtained from grizzly bears observed in coastal Alaska study areas.*

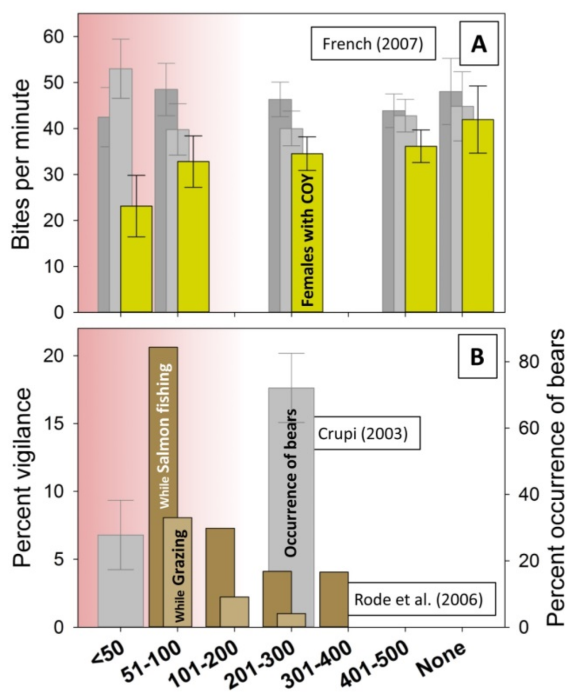


Figure 14. *Grizzly bear behaviors and activity as a function of nearness of pedestrians, differentiated by (A) foraging rates of sex-, age-, and reproductive classes and (B) vigilance or overall levels of bear activity while grazing or salmon fishing. All three studies occurred in coastal areas of Alaska.*

Changes in bear behaviors as a function of distance between bears and pedestrians are a corollary to differences in behaviors with and without people present. Several investigators, again in coastal Alaska, documented changes in bear behaviors or overall levels of bear activity relative to increasing nearness of pedestrians (Crupi 2003, Rode et al. 2006a, French 2007), exclusive of the more overt responses that I cover in Sections 3a-3d. Rode et al. (2006a) documented increased vigilance of bears in their study area both while both grazing and fishing, with increases most pronounced when people were within 50-100 m (Fig. 14B). Crupi (2003) similarly found a pronounced drop in overall bear activity within 100 m of where humans tended to concentrate (Fig. 14B). On the other hand, French (2007) found that only females with COY exhibited a substantial but gradual decrease in foraging activity, albeit most pronounced when people were within 50 m (Fig. 14A). Foraging by other bears seemed unaffected. Taken altogether, this research suggests that pedestrians have a substantial impact on bear foraging and vigilance when nearer than 50-100 m, and that these impacts tend to be greatest for females with COY.

The one proviso to this conclusion again pertains to bears that are tolerant of pedestrians, in most instances judged to be “habituated” by the involved researchers (Aumiller & Matt 1994, Smith 2002, Nevin & Gilbert 2005a, Marshall 2008), but also including bears otherwise motivated to abide people as means of occupying spaces vacated by less tolerant bears (Herrero et al. 2005). Crupi (2003) scored individual bears for their intolerance of pedestrians based on the time they spent at different distances from people, which avoided the pitfalls of a binary approach based on judging whether a bear was “habituated” or not. Compared to foraging by more tolerant bears, Foraging by less tolerant animals was far more impacted by people when within 500 m (Fig. 15).

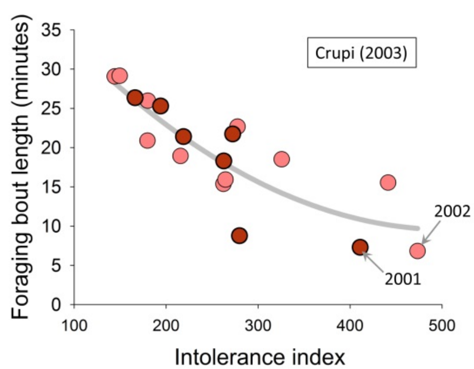
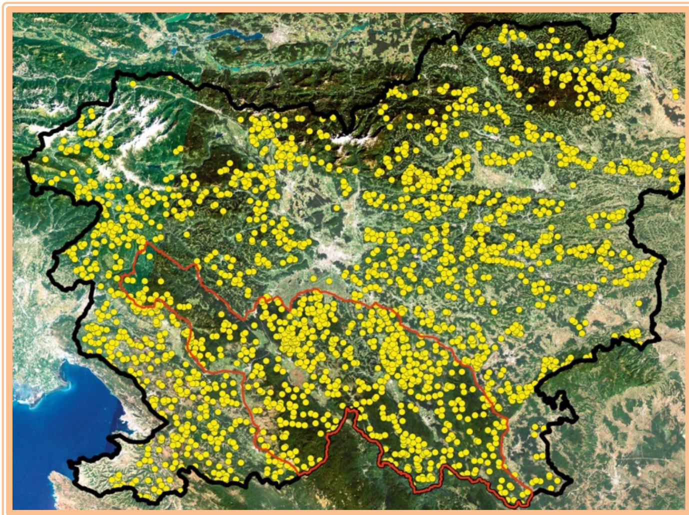


Figure 15. *Relation between length of foraging bouts and level of tolerance (i.e., intolerance) for humans among bears exposed to humans nearer than 500 m in a coastal study area of Alaska*.

White et al. (1999) report results from research conducted in alpine areas of Glacier National Park that support conclusions relevant to foraging efficiencies that would otherwise be based solely on research in coastal areas. They investigated the impacts of pedestrians on grizzly bears consuming moths in alpine talus and found that bears spent 53% less time foraging after people had been detected, while aggressive behaviors increased 23% and time spent moving increased by 52%. Estimated energy expenditures increased by around 12 kcal per minute after disruptions, amounting to a major energetic toll on affected bears.



6. Avoidance of Pedestrians and Pedestrian Infrastructure

I use "avoidance" here, not as a phenomenon categorically distinct from "displacement," but rather as a term encompassing reactions by grizzly bears to pedestrians that are more durable and more often transmitted inter-generationally compared to transient responses. By this distinction, displacement is a finer-grained response by individual bears to the varied presence of pedestrians at the scale of weeks, whereas avoidance manifests as individual bears choosing whether or not to be in areas typified by human activity in the first place.

Given this resolution of response, avoidance necessarily organizes around specific places and even times with enough pedestrian activity to engender predictability for affected bears and allow for codification in their memory. As a result, investigations of avoidance can employ coarser-grained methods such as radio-telemetry to document patterns of bear activity in relation to static features such as trails and campsites that are proxies, not only for the presence of people, but also for spatially-explicit histories of interactions between people and bears. Even so, the conceptual boundary between "avoidance" and "displacement" is inescapably muddy.

Given the centrality of the pedestrian infrastructure to habitat management, I've organized what follows according different human features, including trails, campsites, and broader-scale areas either subject to closures designed to benefit grizzly bears or overrun by people during certain times of year.

6.a. Responses to Trails

With one notable exception, the handful of studies that investigated broad-scale distributions of grizzly bears relative to trails showed avoidance (Kasworm & Manley 1990, Graves 2002, Donelon 2004; Fig. 16). These results held for both daytime-biased studies that relied on VHF technology for radio-tracking (Kasworm & Manley 1990; Mace & Waller 1996), as well as the two studies that deployed GPS collars with round-the-clock data collection (Graves 2002, Donelon 2004). This 24-hour tracking controlled for diel bias in data collection that potentially arose from grizzly bears selecting for crepuscular and night-time hours when exposed to pedestrian traffic—including on trails (Coltrane & Sinnott 2015; Figs. 11A & 17). Averaged over studies, grizzly bears avoided areas within 270 m (SD = 81 m) of trails, with maximum documented avoidance of around 450 m for bears exposed to a single-track trail that had both pedestrian and motorized activity (Graves 2002, Fig. 16B). Mace & Waller (1996) similarly showed that during summer and fall grizzly bears ranged at distances that averaged 1.4-1.8 times greater than would have been expected if bears were distributing themselves randomly relative to trails (Fig. 16D).

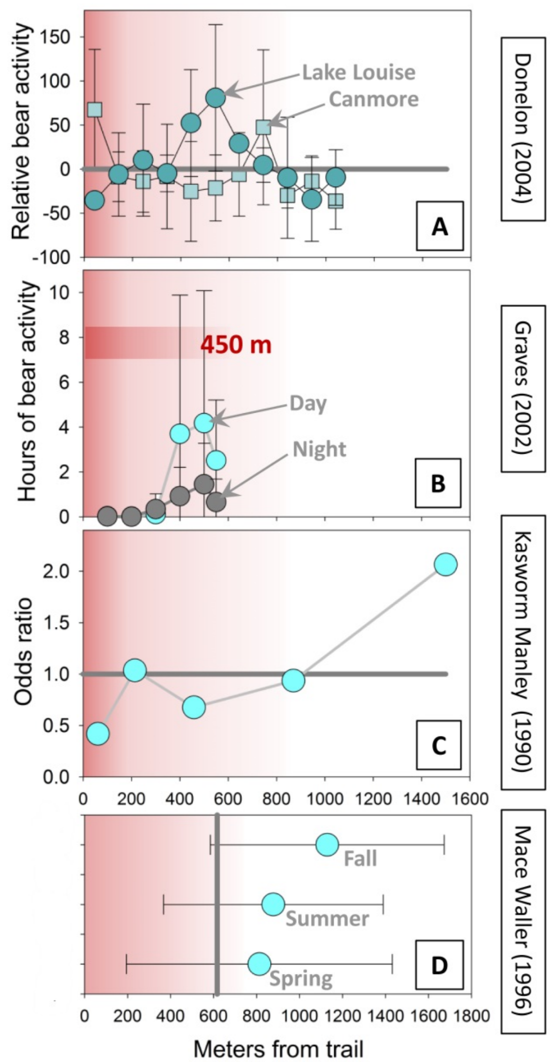


Figure 16. *Distributions of grizzly bears relative to trails, with distance increasing from left to right. Results in (A) and (B) are from GPS-based studies, including distributions relative to random (the benchmark horizontal gray line) in two different study areas (A), and levels of bear activity during both day and night after controlling for extraneous effects (B). VHF-based results in (C) likewise show levels of bear occupancy relative to a random expectation, and in (D) average distances of radio-tracked bears from trails during three seasons, likewise relative to random, shown as a vertical gray bar.*

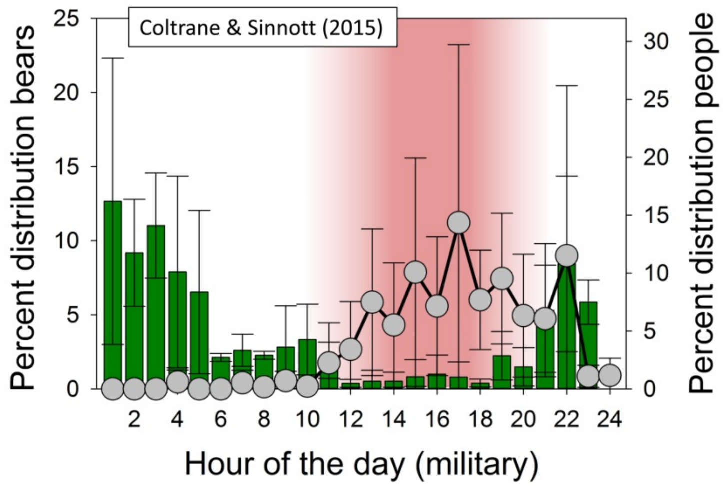


Figure 17. *Percent distributions of grizzly bear and pedestrian detections on trails near Anchorage, Alaska, by hour of the day. Bear detections are shown as green bars, pedestrian detections as gray dots, and time of non-overlap in burgundy shading*.

The noteworthy exception to what would otherwise be a consensus among studies comes from data collected near trails around Canmore, Alberta, just outside of Banff National Park, where grizzly bears selected *for* areas near trails (Donelon 2004; Fig. 16A). This result is somewhat inexplicable given that data collected during the same study from around nearby Lake Louise showed avoidance (Fig. 16A), and in both areas grizzly bears were displaced to nocturnal hours by pedestrian traffic (Fig. 11A). The most likely explanation for this oddity is that the data were collected from highly tolerant bears, with tolerance facilitated by the exceptional levels of pedestrian activity around Canmore (Donelon 2004) and the nearness of protected areas in Banff National Park.

6.b. Responses to Backcountry Campsites

Backcountry campsites warrant being differentiated from trails simply because people are more often present 24-hours a day at campsites rather than solely during daytime hours as on trails (Fig. 11, including 11C; Fig. 17). This matters functionally because grizzly bear otherwise gravitate towards crepuscular and nocturnal hours as a primary compensatory reaction to pedestrians—whether reckoned as displacement or avoidance.

Research is unanimous in showing avoidance of campsites by grizzly bears, but by distances even greater than evident around trails. Averaged across studies (Zunino 1981, Nadeau 1987, Gunther 1990, Mattson 1990, Coleman et al. 2013a; Fig. 18A), bears avoided campsites by around 550 m (SD = 300 m), or, during fall in one study area, ranged at distances more than 1.8-times greater than expected by chance (Mace & Waller 1996; Fig. 18B)). Within these areas of avoidance, bear occupancy was as much as 65-67% less than would have otherwise been expected (Gunther 1990, Coleman et al. 2013a).

One potential caution against unqualified acceptance of these results, again, arises from potential bias towards daylight hours introduced by visual observations (Gunther 1990) or by radio-telemetry data collected using VHF technology (Mattson 1990). Nonetheless, results from Coleman et al. (2013a) based on GPS data (Fig. 18A) and from Nadeau (1987, 1989) using night-vision equipment show high levels of campsite avoidance comparable to that evident from VHF-based investigations, albeit with the proviso that Nadeau (1987, 1989) found increased levels of nocturnal activity by grizzly bears when campsites were occupied by people.

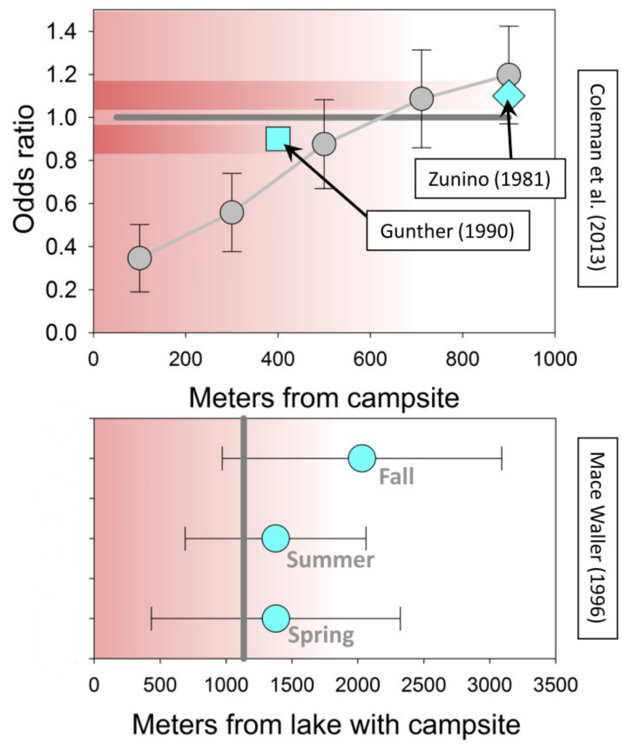


Figure 18. *Distributions of grizzly bears relative to campsites, with distance increasing from left to right. Results from Coleman et al. (2013a) are based on GPS technology and feature distributions of bear locations relative to random (the benchmark horizontal gray line). The blue diamond and square in (A) denote zones of avoidance documented in two studies that did not rely on radio-telemetry. Results using VHF-based technology in (B) show average distances of radio-tracked bears from campsites during three seasons, likewise relative to random, shown as a vertical gray bar.*

6.c. Responses to Seasonal Area Closures

Yellowstone National Park introduced an unusual program in 1982 that seasonally restricted or, in places, altogether precluded dispersed backcountry pedestrian activity in areas known to receive heavy use by grizzly bears (e.g., Hoskins 1975, Chester 1980). These Bear Management Areas (BMAs) encompass 21% of the Park's backcountry, including cutthroat trout (*Oncorhynchus clarki*) spawning streams and open valleys and rugged mountains heavily used by grizzly bears for seasonal foraging.

Some BMAs are closed year-round whereas others allow for restricted or even unrestricted seasonal pedestrian use. These latter BMAs have provided researchers with a unique opportunity to investigate broad-scale reactions of grizzly bears in a lower-density population to dispersed pedestrian activity that is nonetheless seasonally highly predictable.

Most of the research documenting how Yellowstone grizzly bears have reacted to seasonal area closures comes from Gunther (1984, 1990) and, more recently, Coleman et al. (2013b), who found that grizzly bears increased the distances at which they ranged relative to landscape features seasonally used by pedestrians in lock-step with levels of human activity (Fig. 19B). The greater the activity in BMAs, the greater the avoidance of areas used by pedestrians. These authors likewise found that, as under so many other circumstances, bears shifted activity from daylight to nocturnal hours (Fig. 11B). Gunther (1990) similarly found that grizzly bears reduced their daytime movements into the open areas of Pelican Valley when this BMA was opened to human use (Fig. 19A). And, at a coarser-scale yet, he found that grizzly bear activity along a major cutthroat trout spawning stream tributary to Yellowstone Lake substantially increased after restrictions were imposed on angler activity, although with the beginnings of an upward trend occurring the year before (Gunther 1984; Fig. 20).

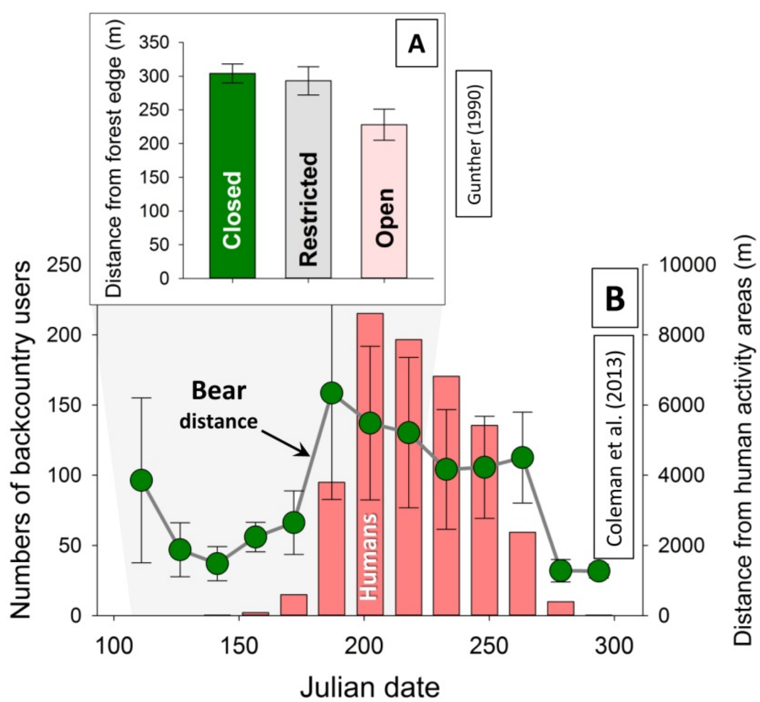


Figure 19. *Responses of grizzly bears to seasonal closures of Bear Management Areas in Yellowstone National Park, (A) reckoned in terms of distances that bears ranged from forest edge in Pelican Valley during closed, restricted, and open periods (Gunther 1990), and (B) average distances of bears from areas of concentrated human activity in BMAs relative to levels of backcountry pedestrian traffic (Coleman et al. 2013b).*

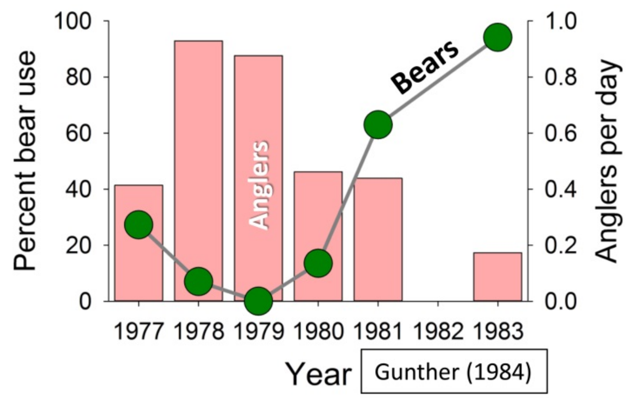


Figure 20. Numbers of anglers and grizzly bears active near the fish weir on Clear Creek in Yellowstone National Park annually between 1977 and 1983.

Although seasonal or year-round closures centered on BMAs were established in Yellowstone Park in the absence of unequivocal proof that they would yield benefits for grizzly bears, subsequent research demonstrated the efficacies of this proactive move by Park Service managers.

But this kind of foresight is not unprecedented or unique to Yellowstone Park. The Confederated Salish-Kootenai Tribes closed the McDonald Peak area in the Mission Mountains of Montana earlier yet, in 1981, to protect grizzly bears foraging on alpine insect aggregations (Klaver et al. 1986). Glacier National Park more recently instituted similar seasonal closures in areas with concentrations of bears on the Apgar Mountains (Kendall 1983) and flanks of Mounts Altyn and Henkel to reduce hazards for pedestrians and increase security for bears (Glacier National Park 2010).

In both of these latter cases, as in Yellowstone National Park, seasonal area closures were implemented in the absence of definitive evidence of prospective efficacy and, instead, largely on the basis of first principles; i.e., grizzly bear conservation will be aided and human safety enhanced by restricting dispersed pedestrian activity in highly-productive habitats heavily-used by bears.

6.d. Other Responses to Dispersed Seasonal Human Activity

Other than research focused on BMAs in Yellowstone National Park there has been few investigations of how seasonally predictable pedestrian activity dispersed over larger areas affects grizzly bears. Notably, MacHutchon et al. (1998) documented roughly 1.4-times more grizzly bear activity along coastal rivers in British Columbia that received relatively little pedestrian use compared to those that were heavily used, presumably because bears, in aggregate, avoided more impacted areas. Novikov et al. (1969) similarly observed that grizzly bears in areas near Leningrad, as it was known then, were displaced by the numerous people who fanned out during summer in the backcountry collecting mushrooms and picking berries, with resulting avoidance of heavily-impacted areas by bears. Concerns about comparable deleterious effects on grizzly bears led the province of British Columbia in Canada to restrict commercial picking of huckleberries (*Vaccinium membranaceum*) in areas heavily used by bears (https://news.gov.bc.ca/releases/2019FLNR0186-001439).

Otherwise, the most significant research on effects of dispersed pedestrians was reported by Ordiz et al. (2012), focused on seasonally regulated bear hunting in Sweden. Their most notable result was documentation, yet again, of a diel shift in activity of bears subject to hunting from daylight to nocturnal hours in defiance of what would have been otherwise expected with seasonal changes in times of sunrise and sunset (Fig. 21)—plausibly to avoid day-active bear hunters.

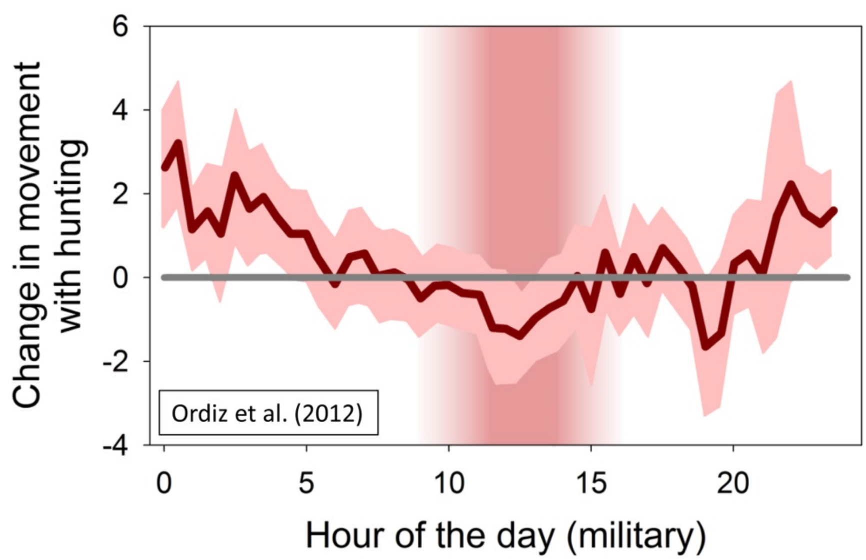


Figure 21. *Change in length of grizzly bear movements during bear hunting season in Sweden relative to background periods and levels expected with the seasonal progression of sunrise and sunset. The horizontal gray line denotes no change; the dark burgundy line, mean observed change; and the light burgundy band 95% confidence intervals for the mean*.

Conversely, research from the Yellowstone ecosystem of Montana and Wyoming revealed a net movement of grizzly bears from the protected environs of Yellowstone National Park *into* areas where elk hunting was underway (Ruth et al. 2003, Haroldson et al. 2004). Compared to other times of year, grizzly bears that ranged across the Park boundary were 2.3 to 4.4-times more likely to be outside of the Park during elk hunting season in areas where hunters were concentrated. The important distinction here is that, in contrast to Sweden, grizzly bears were not the animals being hunted. Elk hunters who were not an overt threat were instead inadvertently providing bears with food in the form of residuum from kills, locally known as "gut piles." Under these circumstances, where people were closely identified with food, bears gravitated towards rather than avoided dispersed pedestrians—with problematic consequences for both bears and people (see Section 4.d.; Herrero 2002, Haroldson et al. 2004).

6.e. Responses of Different Sex-, Age-, & Reproductive-Classes

Despite the amply generalizable responses of grizzly bears to the pedestrian infrastructure, there is also substantial subsidiary variation among bears that is largely related to an interaction between the predictability and intensity of human activity, and the sex-, age-, and reproductive-class of involved bears. Entangled with all of this, though, are idiosyncratic differences in tolerance of humans.

Resource-rich coastal spawning streams where people are predictably concentrated in time and space constitute a singular environment that precludes free extrapolation of associated research results to other contexts (see Section 1.b), although even here there is variability in results among studies. In the main, though, adult females, especially when accompanied by young, tended to be disproportionately represented among bears using areas near concentrations of people (Warner 1987, Van Dyke 2003, Rode et al. 2006b). Adolescent bears were also often disproportionately common (MacHutchon et al. 1998, Van Dyke 2003). Both of these classes of bears probably used humans as a shield to avoid potentially infanticidal or otherwise murderous adult males (e.g., Nevin &Gilbert 2005a, 2005b; Elfström et al. 2014; Steyaert et al. 2016) which, all else equal, tended to avoid people (e.g., Fischbach & Reynolds 2005, Rode et al. 2006b).

These sorts of results have been replicated in interior regions typified by lower densities of bears, but only under circumstances where people were likewise concentrated in predictable ways, almost always along roads and in residential areas (e.g., Mattson et al. 1987; McLellan & Shackleton 1988; Mueller et al. 2004; Roever et al. 2008; Graham et al. 2010; Cristescu et al. 2016). There are no studies showing that females with young used humans as a putative "shield" under circumstances involving pedestrians on trails or at campsites.

In interior regions most of the research of relevance to judging how different types of grizzly bears disport themselves relative to pedestrians once again comes from Glacier National Park. Here, the main pattern was a tendency for females with COY to under-represented in areas with heavier pedestrian traffic (e.g., >1.5 people/hour on trails)—by as much as 33-50% (Jope 1983, Nadeau 1987)—coupled with a tendency for adolescents and lone adults to be more common in these human-impacted areas (Fig. 22). Leonard et al. (1990) likewise found a tendency for solitary bears to become more common as numbers of pedestrians increased, but at a very low threshold of human activity in an area typified by very little pedestrian traffic.

All of these patterns are conditioned, though, on the differential extent to which individual bears are tolerant of humans, whether as a consequence of habituation or as a result of the drive to find security from other bears and related freer access to resources—although these two phenomena are almost always closely linked (Herrero 2002, Herrero et al. 2005). The results that I summarized in Section 5.a. (including Figure 10), although of more direct relevance to displacement, are also relevant to avoidance. Even within classes of bears evincing generally greater avoidance of pedestrians, more tolerant (e.g., "habituated") bears can be differentiated from less tolerant bears, with tolerant bears more often selecting for areas near pedestrians (Olson et al. 1994, 1997; Smith & Johnson 2004).

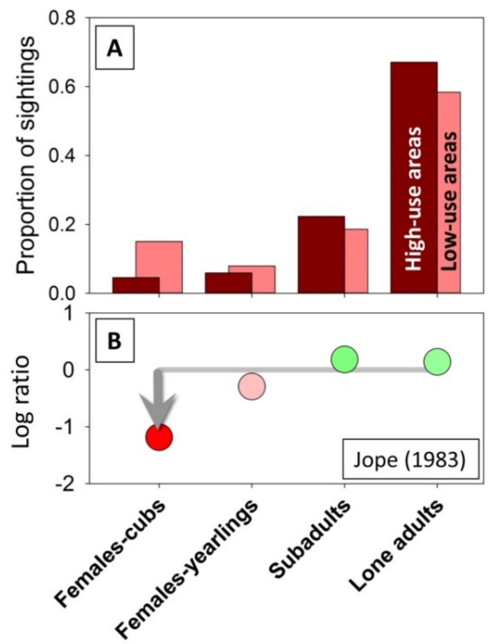


Figure 22. (*A) Proportion of grizzly bear sightings in Glacier National Park comprised of different sex-, age-, and reproductive-classes differentiated by areas of heavy versus low levels of pedestrian activity, represented as (B) a log-transformed ratio of the proportions for each class.*

Moreover, tolerant bears also can be differentiated from intolerant bears by the degree to which they select for times of day when people are more or less active (Olson et al. 1998). Wheat and Wilmers (2016) offered perhaps the most compelling evidence (Fig. 23) for differences in avoidance on a diel basis between "habituated" and "non-habituated" bears that is not only relevant to the coastal study area where they collected their data, but also to interior regions with lower densities of bears. Not surprisingly, tolerant bears selected for times of day when people were more active whereas intolerant bears tended to avoid these same diel periods.

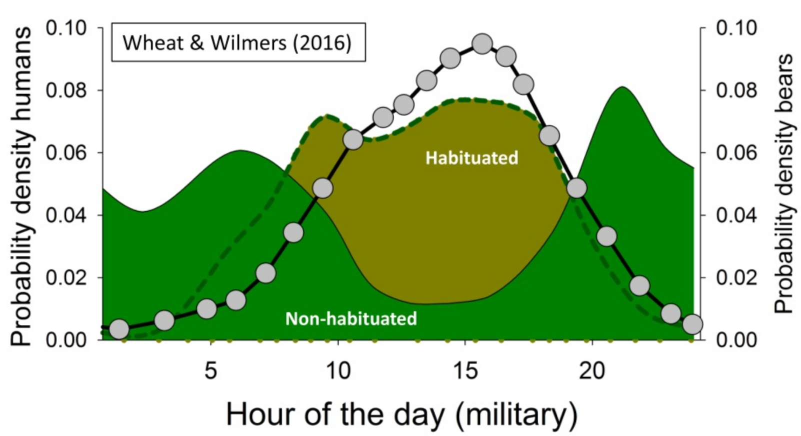


Figure 23. Diel distribution of activity by habituated and non-habituated grizzly bears (yellow-green versus dark green shading) relative to levels of human activity (gray dots) in a coastal study area.

7. Summary and Conclusions

With necessary allowance for subsidiary dynamics, the unambiguous main theme of the research I've summarized here is that the presence of pedestrians harms grizzly bears to some extent under most circumstances. This harm can be of shorter or longer duration, manifest in flight, displacement, or avoidance—but it is harm nonetheless.

With that having been said, reactions of grizzly bears to pedestrians are obviously conditioned on histories of persecution by humans, the nature and intensity of interactions with other bears, and individual life experiences. Cultural transmission and transference from experiences with other bears clearly influence how bears respond to humans under any circumstances. Importantly, the ground state of grizzly bears is probably not one of fear, but rather ambivalence towards humans (Russell & Enns 2002, Stringham & Rogers 2017). Fear is likely learned, either through immediate experiences or, perhaps most commonly, by learning from other bears. Likewise, fear can wane and tolerance increase as an outcome of benign experiences, with encounters often catalyzed by bears gravitating towards human-impacted environs seeking safety from other bears or freer access to resources.

With these important provisos in mind, there are several generalizable conclusions that can be derived from research on how pedestrians affect grizzly bears:

- Grizzly bears manifest greater reactivity to pedestrians in several different ways, including greater likelihood of both flight and aggression during encounters, greater likelihood of spatial and temporal displacement, and greater avoidance of areas and times of day frequented by pedestrians.

- As a tautology, grizzly bears that are less reactive are more tolerant, with tolerance arising from either habituation to the presence of pedestrians or the need to abide nearby people as a prerequisite for accessing food or security from other bears.

- Grizzly bears likely transfer tolerance for other bears to pedestrians, with tolerance for conspecifics most evident in high-density coastal bear populations. The greater the intraspecific tolerance, the less reactive bears are likely to be during encounters with people.

- Benign human activities that are highly predictable in time and space lessen the likelihood of surprise encounters and allow for the emergence of tolerance among bears, both of which predictably lessen reactivity by bears.

- High levels of tolerance for pedestrians are most evident in areas with high densities of bears together with pedestrians concentrated in specific locales at specific times of day. The classic example of this circumstance is where anglers or bear viewers are closely regulated while near coastal salmon spawning streams.

- Under such conditions, adolescent grizzly bears and females with cubs-of-the-year (COY) often concentrate near pedestrians as means of escaping intraspecific competition as well as hazards posed by potentially predatory adult males. Under these circumstances, pedestrians plausibly serve as a "shield" for more security-conscious or subordinate bears.

- In the absence of spatially and temporally highly-predictable activity typically associated with heavy pedestrian traffic, there is essentially no evidence that pedestrians serve as "shields." This important proviso covers almost all of the backcountry of interior North America.

- All other circumstances aside, individual bears that are more tolerant of pedestrians are less likely to be displaced by or avoid people. Compared to intolerant bears, tolerant bears are also more likely to be efficient foragers when pedestrians are nearby (nearer than 50-100 m).

- Even so, there is ample evidence that grizzly bears in coastal regions are, in aggregate, displaced by pedestrians, most commonly to times of day that are suboptimal for foraging. Absent avoidance and high levels of tolerance, foraging efficiencies are also commonly impaired by the presence of pedestrians especially when within 150 m.

- In interior regions, grizzly bears react more strongly to encounters with pedestrians when they are "startled" or "surprised," which more often happens at distances of less than 30 to 150 m, typically in areas with greater vegetation cover and the obscuring sound of running water. Strong reactions predominantly include flight (during roughly 70% of encounters), but also aggression (during roughly 4-6%). Human injury is likely to occur during only 3-6 out of every 1000 encounters.

- Grizzly bears are more likely to react strongly to encounters with pedestrians in open areas, including alpine areas and grasslands, as well as in areas *less* heavily used by people. Both circumstances predictably increase the odds that involved bears will feel both threatened and surprised.

- Compared to other bears, females with COY are far more likely to react strongly to encounters with pedestrians, most notably by 4 to 7-times more often charging the involved people. This greater reactivity almost certainly arises from defense of vulnerable offspring.

- After encounters, grizzly bears in interior regions flee on average nearly 2 km, increase levels of activity for 24-72 hours afterward, shift activity towards nocturnal and crepuscular hours, and select for areas of greater cover, all of which entail predictable energetic costs.

- Grizzly bears avoid areas near backcountry trails by an average of 250 m and backcountry campsites by an average nearer 550 m, while additionally selecting for night-time hours when near backcountry pedestrian facilities, presumably to avoid day-time concentrated human activity.

- Grizzly bears also avoid areas seasonally closed to dispersed pedestrian activity during times of year when these areas are open to human use, with impacts compounded by decreased use of open areas and more marked avoidance of areas where pedestrian activity is concentrated.

- As an exception to what would otherwise be a rule, grizzly bears are attracted to areas where big game hunters provision bears with food in the form of remains from ungulate kills, but with resulting increased risks to hunters arising from surprise encounters and the contestation of carcasses with bears.

- Compared to other bears, females with COY tend to exhibit greater avoidance of heavily-used pedestrian facilities, whereas adolescent bears tend to more often seek out areas with more human activity presumably to find security from dominant adult bears and to more freely access food.

- Overall, displacement and avoidance are most consistently exhibited by grizzly bears in the form of increased activity during nocturnal and crepuscular hours and diminished activity during daylight hours when people are most active.

- Overall, females with COY are most impacted by the presence of pedestrians, with implications for human safety. The notable exception to what would otherwise be a rule is in areas with heavy, concentrated, and predictable pedestrian activity, where females can find refuge for their cubs near people from threats posed by predatory adult males.

8. Applications

The synopsis and interpretation of research presented here have obvious relevance to specific applications, but with due regard for the contingencies of context. Two issues of regional importance to management of grizzly bears in the contiguous United States are each illustrative in different ways of potential applications of research on how pedestrians have been found to affect grizzly bears. The one pertains to potential impacts of mountain bikers under circumstances where there is little directly relevant research, but where there is nonetheless defensible scope for extrapolation of research results presented in this report. The other pertains to proposed upgrading and construction of a trail for through-hikers (the Pacific Northwest National Scenic Trail, or PNT) that will be part of a national infrastructure and transects some of the most secure habitat left for a critically endangered grizzly bear population in the Yaak region of Montana. This case is illustrative of contextual applications that necessarily consider grizzly bear population status, geospatial configurations, particulars of habitat, and the nature of foreseeable pedestrian activity.

8.a. Effects of Mountain Bikers on Grizzly Bears

Mountain bikers occupy a conceptual middle-ground between pedestrians and people on or in motorized transport. They do not employ noisy mechanized equipment that potentially gives advance warning of their progress, but at the same time they move at potentially high speeds. Unlike people enclosed in hard-sided mechanized vehicles, but like people riding off-road-vehicles (OHV) or on foot, they are exposed to the risks of physical injury from an attacking grizzly bear. Given these provisos, mountain bikers qualify for extrapolation of the results in this report, primarily because of their comparative silence as well as vulnerability.

Apropos, Brad Treat was killed by a grizzly bear in June of 2016 after essentially colliding with the bear while he was travelling at high speed on a mountain bike along a trail with limited visibility (Servheen et al. 2017). This incident elevated the profile of risks for both people and bears posed by mountain biking, although a number of similar incidents had highlighted the hazards of mountain biking in Canada as much as 20 years earlier. Concern about risks were also magnified by the fact that mountain biking is becoming more popular in areas occupied by grizzly bears, reflective of the 28% increase nationwide in this activity during the last 10 years (Outdoor Foundation 2017).

The few investigations of encounters between bikers and grizzly bears paint a stark picture (Schmor 1999, Herrero & Herrero 2000, Honeyman 2007, Servheen et al. 2017). Data pooled from all of these reports show that 87% (± 4.6%) of all documented encounters were at distances less than 50 m, and that 52% (± 10%) involved females with young. Of these close encounters, 89% (± 6%) resulted in the biker either being approached or charged by the involved bear. Not surprisingly, of the 41 encounters described by bicyclists interviewed by Schmor (1999), bears were described as being “startled” during 66% of them.

These risk-related figures are far in excess of the averages I present in Sections 3 and 4 of this report. The percent of encounters that elicited some kind of aggressive response from involved bears is an astounding 14-times greater for mountain bikers compared to for pedestrians. Even if, compared to pedestrians, a greater number of "encounters" went undetected by mountain bikers, this alone would not account for the magnitude of this disparity. Moreover, the obvious heightened reactivity of bears to mountain bikers is not surprising given that average encounter distances were closer for bikers compared to the average 70-90 m involving pedestrians—and well within the Overt Reaction Distance (ORD) of most grizzly bears (Herrero et al. 2005).

These results are not unexpected. As Herrero & Herrero (2000) noted nearly 20 years ago, mountain biking is a perfect recipe for hazardous close encounters with grizzly bears given that bikers are often traveling silently at comparatively high speeds (11-30 km per hour; Schmor 1999), which increases the odds of rapid closure prior to detection along with amplified reactivity among even highly tolerant bears. This same point has subsequently been made in several assessments of hazards posed by mountain biking in grizzly bear habitat (Honeyman 2007, Quinn & Chernoff 2010, MacHutchon 2014).

The disproportionately large number of encounters between mountain bikers and female grizzly bears with young is also not surprising. If a person is approaching at high speed, solitary bears are plausibly better able to detect the approach and leave before being seen. By contrast, females with young are predictably challenged and delayed by marshalling their offspring before being able to depart, even if they detect an oncoming bicyclist at a distance. The plausible outcome is an encounter at close range with a highly reactive female grizzly bear mobilized in defense of her young.

The flip side of this dynamic between mountain bikers and grizzly bears is the likely short- and long-term impacts on involved bears. Greater immediate reactivity on the part of bears almost certainly translates into more rapid and sustained subsequent flight (Section 3.b.), along with longer-term energetic and physiological costs associated with impaired foraging, increased movements, and displacement of activity to suboptimal times of day (Sections 3.c., 3.d., and 5.b.).

The weight of evidence unambiguously supports concluding that mountain biking is far more hazardous for involved people and more impactful on affected bears compared to any other pedestrian activity with the exception of hunting. Given this perhaps self-evident verdict, it is not surprising that Parks Canada seasonally or permanently closed trails to mountain bikers several years ago in areas where chances of hazardous encounters were high (e.g., the Minnewonka, Mortaine Lake Highline and Bryant Creek trails [MacHutchon 2014]).

8.b. Effects of the Proposed Pacific Northwest Trail (PNT) on Yaak Grizzly Bears

My intent here is not to undertake a comprehensive assessment of impacts likely arising from the PNT, but rather to highlight the relevance of results presented in this report. Craighead et al. (2018) and Mattson (2019) provide a more complete overview of context for the PNT, including status of the local grizzly bear population and particulars of the trail placement relative to broad and fine-scale habitat conditions. Nonetheless, a brief overview of this context is necessary for judicious application of research in this report to an assessment of how pedestrians using the PNT may affect grizzly bears.

Notably, the density of grizzly bears in the Yaak population is among the lowest of any in North America (4.3-4.5 bears per 1,000 km^2; Kendall et al. 2016), not by virtue of intrinsic carrying capacity (Mattson & Merrill 2004), but rather as a result of a long history of persecution by Europeans. This small population of between 20 and 25 grizzly bears is also isolated demographically from grizzly bears anywhere else, albeit with some genetic exchange with bears farther north (Proctor et al. 2012, 2015, 2018). Humans are not numerous in this region (around 2 residents per km^2), nor is human activity in the backcountry currently heavy, especially in comparison to Montana's nearby Glacier National Park (c. 1.5 million hikers per year) and Flathead National Forest (c. 1,000,000 visitors per year).

The main cause of death for adolescent and adult bears here is malicious or otherwise unjustified killing by people, followed by being mistaken for a black bear (*Ursus americanus*) by licensed bear hunters (Kasworm et al. 2018, Mattson 2019). The upshot is that the status of this population is highly precarious, with loss of even one additional female every two years likely to cause decline to functional extirpation (Mattson 2019). Given the predominance of malicious killing, any additional human access poses a threat, as does any displacement of grizzly bears from otherwise secure habitat into areas with human habitations or a road network.

Background on the PNT

The PNT was first proposed in the 1970s, leading to a government study of feasibility and potential impacts that was completed in 1980 (US Forest Service & National Park Service 1980). The associated report concluded that there would be significant adverse environmental impacts on both grizzly bears and open subalpine habitats arising from a proposed trail location that transected the heart of the Yaak region at higher elevations. During this same period an independent evaluation by Jonkel & McMurray (1978) recommended relocating the proposed route farther south to parallel the Kootenai River and existing US Highway 2/Burlington Northern-Santa Fe railway transportation corridor for most of its length. Construction of the trail was not pursued because of prospective environmental impacts as well as economic infeasibility.

Nonetheless, the US Congress mandated construction of the trail in 2009 as part of the National Trails Act. Since then deliberations have centered on the relative experiential and environmental merits of trail location, including comparative impacts on grizzly bears, but with clear preference by the US Forest Service for the original northern location through the heart of the Yaak region. With completion of the PNT, trail use is expected to increase on existing segments by 100-150 hikers per season during the near future, with most use prospectively concentrated during July-September, coincident with grizzly bear hyperphagia (Schwartz et al. 2003).

Grizzly Bear Diets and Habitats

Grizzly bears in the Yaak region and adjoining ecosystems heavily consume fruit during July-September, with peak consumption during August (McLellan et al. 1995, Kasworm et al. 2018). Of this fruit, huckleberry (*Vaccinium membranaceum*) is consumed most heavily, with demonstrable effects on bear distributions and interactions with humans (McLellan 2015, Proctor et al. 2017, Kasworm et al. 2018). During their active season, bears tend to concentrate in and near productive huckleberry patches (Proctor et al. 2017). But during years when huckleberries are scarce, bears more often venture into areas where they are exposed to humans and then die at higher rates (McLellan 2015, Kasworm et al. 2018). As a plausible corollary, any human activity that displaces bears from productive huckleberry patches will produce a functionally similar dynamic that takes a demographic toll.

In areas of British Columbia adjacent to the Yaak region, huckleberry patches and associated concentrations of grizzly bears are disproportionately concentrated at higher elevations on gentler slopes with heavier snowpack and greater summer precipitation—yet with exposure to greater solar radiation (Proctor et al. 2017). These conditions correspond with wet comparatively mild sites where subalpine fir (*Abies lasiocarpa*) and Englemann spruce (*Picea engelmannii*) are climax tree species (Proctor et al. 2017). In the Yaak region, these conditions are concentrated to the west and at elevations between 1435 and 1739 m, just below the highest ridges and peaks (Leawell 2000).

Grizzly bears in the Yaak region also eat an abundance of other vegetal foods, including roots and foliage concentrated in open alpine and high-subalpine habitats (McLellan & Hovey 1995, Kasworm et al. 2018). This consumption of high-elevation herbage and roots manifests as seasonal selection for alpine areas in adjacent areas of British Columbia (Proctor et al. 2017). In the Yaak region, similar high-subalpine environments occur at the highest elevations along ridges and peaks, typically at >1525-1830 m. Here, again, displacement of bears by humans would invariably be towards lower elevations where road access and human residences are concentrated (US Forest Service 2019).

Geospatial Context

The current proposed location of the PNT is almost entirely in or near areas that have been identified as either source or core habitats for grizzly bears (Mattson & Merrill 2004, Proctor et al. 2015). Alternatively, virtually none of the alternate location proposed by Jonkel and McMurray (1978) is located in comparably important habitats. Figure 24A shows the locations of these two routes relative to source and core habitats, with results of Mattson & Merrill (2004) integrated with those of Proctor et al. (2015) showing in darker green areas where grizzly bears are both more concentrated and more likely to survive. The geospatial results are not ambiguous.

The upshot is that pedestrians travelling the current proposed route will be far more likely to encounter grizzly bears compared to pedestrians using the alternate route. This basic conclusion is reinforced by the more overtly descriptive results of Kasworm et al. (2018; Fig. 25A) and Kendall et al. (2016; Fig. 25B) showing that the highest densities of grizzly bear sightings and DNA-based detections are comparatively more concentrated in areas along the current proposed route compared to the alternate route.

Compounding this greater likelihood of encounter between pedestrians and bears, the current proposed route transects either open high-elevation habitats or areas that likely support productive huckleberry patches along the majority of its length (Fig. 24B). These attractive habitats will predictably further concentrate bears along the current PNT route in an area with already the highest densities of grizzly bears, resulting in even greater exposure to trail users than would be expected by chance. By contrast, the alternate route transects neither of these high-value attractive foraging habitats for grizzly bears. Again, the geospatial results are not ambiguous regarding intersection with high-value habitats.

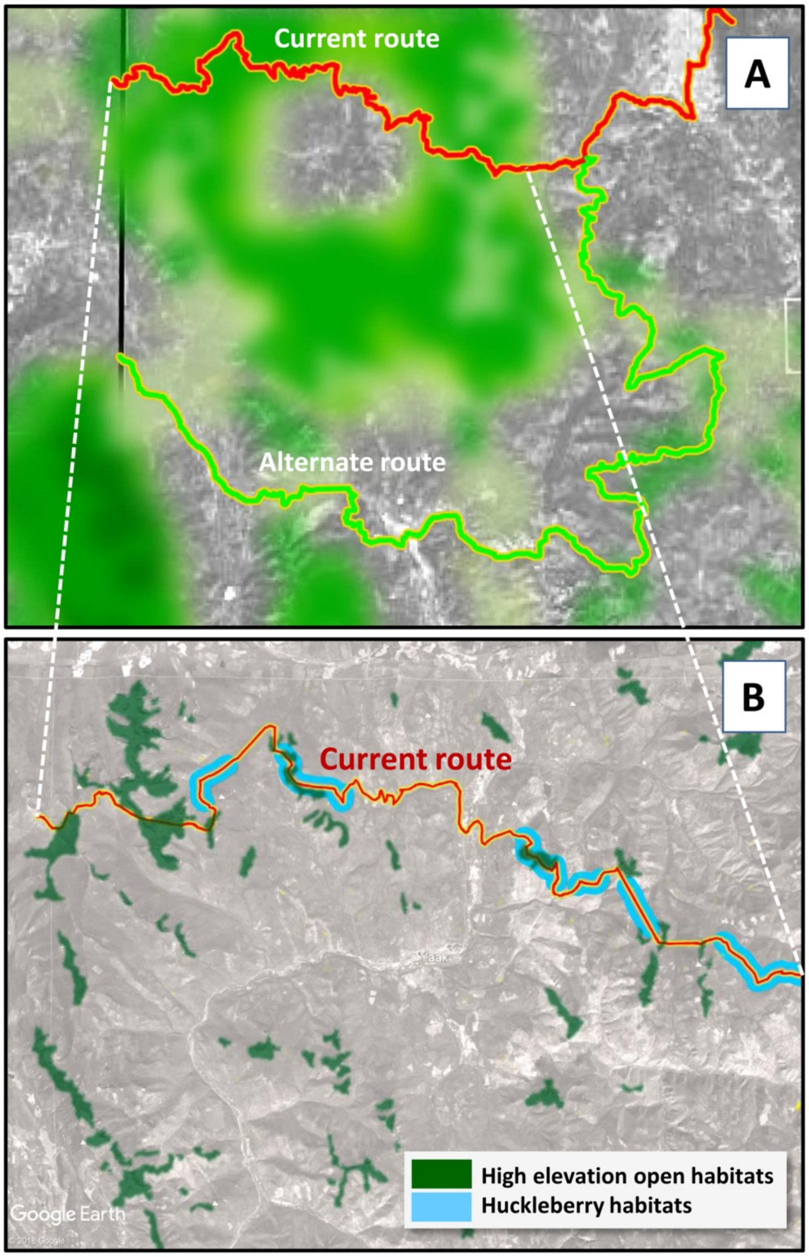


Figure 24. (A) *Locations of the proposed current and alternate routes for the Pacific Northwest Trail through the Yaak region of Montana relative to modeled distribution of core and source habitat for grizzly bears (Mattson & Merrill 2004, Craighead & McMurray 1978); darker green corresponds with greater odds of both. (B) Location of the current proposed route relative to areas with high odds of containing productive huckleberry habitats as well as high-elevation open habitats.*

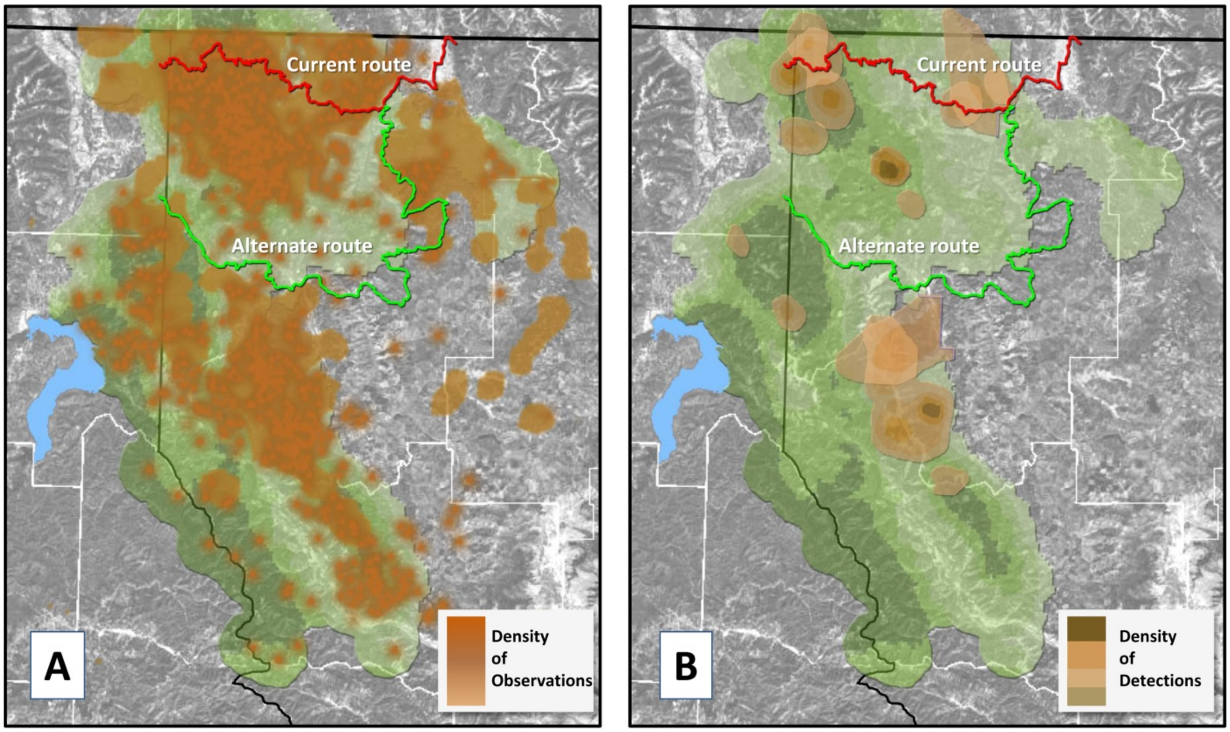


Figure 25. *Location of the current proposed PNT route (red) and alternate Jonkel & McMurray (1978) route (bright green) relative to (A) density of confirmed grizzly bear sightings and sign (Kasworm et al. 2018) and (B) DNA-based grizzly bear detections (Kendall et al. 2016). The gradient of background green shading denotes potential grizzly bear densities under pre-European conditions (Mattson & Merrill 2004).*

Likely Effects of the PNT on Grizzly Bears

Whether judged in absolute or comparative terms, foreseeable pedestrian activity on the proposed PNT is guaranteed to adversely affect the small highly vulnerable population of grizzly bears in the Yaak region. This will arise in part from location of the proposed PNT through the heart of core and source habitats modeled on the basis of selection by radio-marked bears, densities of confirmed bear observations, and distributions of bear mortalities. This coincidence with remote areas of concentrated grizzly bear activity is consistent with distributions of historical observations and DNA-based detections of bears.

Spatial overlap with the highest regional densities of grizzly bears alone guarantees a high likelihood of encounter between trail users and bears with both short- and long-term impacts. But this likelihood will be compounded by juxtapose of the current proposed trail location with habitats known to attract grizzly bears, including open high-elevation habitats where bears are maximally exposed, as well as areas of denser vegetation where close range encounters are likely. This spatial overlap will also be temporal given that seasonal use of these attractive habitats by grizzly bears coincides with when pedestrian traffic on the trail will be heaviest.

Perhaps paradoxically, impacts will likely be exacerbated by low grizzly bear densities and pedestrian traffic light enough to preclude predictability for bears. As emphasized throughout this report, conditions such as these increase reactivity of grizzly bears to humans. For one, there are probably insufficient levels of close interaction to foster mutual tolerance among bears, much less transference of this tolerance to pedestrians. For another, even if trail traffic is confined to daylight hours, foreseeable levels will almost certainly remain below the 1-1.5 hikers per hour constituting the apparent threshold for development of human-specific tolerance and finer-tuned avoidance—yet be heavy enough to guarantee encounters.

Under these circumstances, grizzly bears stand a good chance of being “startled” or “surprised” by trail users, or by simply responding as if encounters posed a threat (Section 4.b.). The predictable result will be high levels of reactivity almost invariably entailing flight, but also including the possibility of initial aggression, especially if females accompanied by dependent young are involved. Encounters between trail users and bears foraging on huckleberries in denser vegetation will be predictably fraught, with the potential for deleterious outcomes for both people and bears.

This potential was highlighted during the summer of 2019 when two hikers on a trail through the Cabinet Mountains immediately south of the Yaak region deployed handguns to shoot a female bear that apparently reacted aggressively when startled while foraging on berries in shrubby vegetation. Given the acute vulnerability of grizzly bear populations in the Yaak region and adjacent Cabinet Mountains, lethal reactions by trail users to encounters such as these will not be sustainable. Nor is lethal response likely to be warranted given the very low rate at which even aggressive reactions by grizzly bears translate into physical harm for involved pedestrians (see Section 4.c.).

Grizzly bears will likely avoid the PNT as a natural consequence of strong reactions to encounters with trail users (Section 6.a.), with resulting alienation from otherwise important foraging habitats and displacement into lower-elevation areas that are likely to be less secure from human-caused mortality. Nor, as some proponents of the PNT have argued, is there any credible chance of females with COY orienting towards trail users as a “shield” against predatory males. As has been emphasized in this report, such behavior has only been documented where densities of grizzly bears are comparatively high and/or where there are heavy levels of spatially and temporally highly-predictable human activity (Section 6.e.). In fact, the more likely response of females with COY will be disproportionately greater avoidance of the PNT compared to other sex-, age-, or reproductive classes of bears (Section 6.e.).

Finally, hazards will be amplified for people and impacts accentuated for bears to the extent that off-trail pedestrian activity increases (Sections 4.b. and 4.c.), the PNT is used by mountain bikers (Section 8.a.), or spur trails are constructed through high-elevation open habitats—all of which are plausible consequences of trail enhancements, including those part of the extensive Black Ram Project being proposed by the Forest Service for northwestern portions of the Yaak region (US Forest Service 2019).

9. References

Aumiller, L. D., & Matt, C. A. (1994). Management of McNeil River State Game Sanctuary for viewing of brown bears. International Conference on Bear Research & Management, 9, 51-61.

Ben-David, M., Titus, K., & Beier, L. R. (2004). Consumption of salmon by Alaskan brown bears: a trade-off between nutritional requirements and the risk of infanticide?. Oecologia, 138(3), 465-474.

Bertch, B., & Gibeau, M. (2009). Grizzly bear monitoring in and around the Mountain National Parks: mortalities and bear/human encounters 1990-2008. Second annual report. Parks Canada, Mountain National Parks, Banff, Canada.

Blumstein, D. T. (2016). Habituation and sensitization: new thoughts about old ideas. Animal Behaviour, 120, 255-262.

Chester, J. M. (1980). Factors influencing human-grizzly bear interactions in a backcountry setting. International Conference of Bear Research & Management, 3, 351-357.

Coleman, T. H., Schwartz, C. C., Gunther, K. A., & Creel, S. (2013a). Influence of overnight recreation on grizzly bear movement and behavior in Yellowstone National Park. Ursus, 24(2), 101-111.

Coleman, T. H., Schwartz, C. C., Gunther, K. A., & Creel, S. (2013b). Grizzly bear and human interaction in Yellowstone National Park: an evaluation of bear management areas. The Journal of Wildlife Management, 77(7), 1311-1320.

Coltrane, J. A., & Sinnott, R. (2015). Brown bear and human recreational use of trails in Anchorage, Alaska. Human–Wildlife Interactions, 9(1), 132-147.

Craighead, F. L., McCrory, W. P., & Cross, B. (2018). Potential impacts of the proposed Pacific Northwest National Scenic Trail route on threatened grizzly bears and their recovery in the Yaak watershed area, NW Montana. Craighead Institute, Bozeman, Montana.

Cristescu, B., Stenhouse, G. B., Symbaluk, M., Nielsen, S. E., & Boyce, M. S. (2016). Wildlife habitat selection on landscapes with industrial disturbance. Environmental Conservation, 43(4), 327-336.

Crupi, A. P. (2003). Foraging behavior and habitat use pattersn of brown bears (Ursus arctos) in relation to human activity and salmon abundance on a coastal Alaskan salmon stream. M.S. Thesis, Utah State University, Logan, Utah.

DeChano, L. M., & Butler, D. R. (2002). An analysis of attacks by grizzly bears (Ursus arctos horribilis) in Glacier National Park, Montana. The Geographical Bulletin, 44(1), 30-41.

Donelon, S. (2004). The influence of human use on fine scale, spatial and temporal patterns of grizzly bears in the Bow Valley of Alberta. M.S. Thesis, Royal Roads University, Victoria, British Columbia.

Egbert, A. L., & Stokes, A. W. (1976). The social behaviour of brown bears on an Alaskan salmon stream. International Conference on Bear Research & Management, 3, 41-56.

Elfström, M., Zedrosser, A., Støen, O. G., & Swenson, J. E. (2014). Ultimate and proximate mechanisms underlying the occurrence of bears close to human settlements: review and management implications. Mammal Review, 44(1), 5-18.

Fischbach, A. S. & Reynolds, J. H. (2005). Brown bear use of the proposed Kodiak National Wildlife Refuge O'Malley Bear Viewing Site: Analysis of 1991, 1992, 1993, 1994 and 2003 study year observations. US Fish & Wildlife Service, Kodiak National Wildlife Refuge, Kodiak, Alaska.

French, H. B. (2007). Effects of bear viewers and photographers on brown bears (Ursus arctos) at Hallo Bay, Katmai National Park and Preserve, Alaska. M.S. Thesis, University of Alaska, Fairbanks, Alaska.

Gende, S. M., & Quinn, T. P. (2004). The relative importance of prey density and social dominance in determining energy intake by bears feeding on Pacific salmon. Canadian Journal of Zoology, 82(1), 75-85.

Gibeau, M. L., Clevenger, A. P., Herrero, S., & Wierzchowski, J. (2002). Grizzly bear response to human development and activities in the Bow River Watershed, Alberta, Canada. Biological Conservation, 103(2), 227-236.

Gill, I. D., & Helfield, J. M. (2012). Alternative foraging strategies among bears fishing for salmon: a test of the dominance hypothesis. Canadian Journal of Zoology, 90(6), 766-775.

Glacier National Park Bear (2010). Bear management guidelines. US Department of the Interior, National Park Service, Glacier National Park, West Glacier, Montana.

Graham, K., Boulanger, J., Duval, J., & Stenhouse, G. (2010). Spatial and temporal use of roads by grizzly bears in west-central Alberta. Ursus, 21(1), 43-57.

Graves, T. A. (2002). Spatial and temporal response of grizzly bears to recreational use on trail. M.S. Thesis, University of Montana, Missoula, Montana.

Gunther, K. (1984). Relationship between angler and bear use in the Clear Creek area of Yellowstone Lake. Pages 185 - 192 in Jones, R. D., Gresswell, R. E., Gunther, K. A., & Lentsch, L. D. Annual Project Report for 1983: fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Gunther, K. (1990). Visitor impact on grizzly bear activity in Pelican Valley, Yellowstone National Park. International Conference of Bear Research & Management, 8, 73-78.

Gunther, K. A. (2015). Risk, frequency, and trends in grizzly bear attacks in Yellowstone National Park. Yellowstone Science, 23(2), 62-65.

Haroldson, M., & Mattson, D. (1985). Response of grizzly bears to backcountry human use in Yellowstone National Park. US National Park Service, Interagency Grizzly Bear Study Team, Bozeman, Montana.

Haroldson, M. A., Schwartz, C. C., Cherry, S., & Moody, D. S. (2004). Possible effects of elk harvest on fall distribution of grizzly bears in the Greater Yellowstone Ecosystem. The Journal of Wildlife Management, 68(1), 129-137.

Harting, A. L. (1985). Relationships between activity patterns and foraging strategies of Yellowstone grizzly bears. M.S. Thesis, Montana State University, Bozeman, Montana.

Herrero, S., & Fleck, S. (1990). Injury to people inflicted by black, grizzly or polar bears: recent trends and new insights. International Conference on Bear Research & Management, 8, 25-32.

Herrero, S., & Higgins, A. (1999). Human injuries inflicted by bears in British Columbia: 1960-97. Ursus, 11, 209-218.

Herrero, J., & Herrero, S. (2000). Management options for the Moraine Lake Highline Trail: grizzly bears and cyclists. Report to Parks Canada, Calgary, Alberta.

Herrero, S. (2002). Bear attacks: their causes and avoidance. Revised edition. Lyons Press, Guilford, Connecticut.

Herrero, S., & Higgins, A. (2003). Human injuries inflicted by bears in Alberta: 1960–98. Ursus, 14(1), 44-54.

Herrero, S., Smith, T., DeBruyn, T. D., Gunther, K., & Matt, C. A. (2005). From the field: brown bear habituation to people—safety, risks, and benefits. Wildlife Society Bulletin, 33(1), 362-373.

Honeyman, J. (2007). Bow Valley bear hazard assessment. Report to Alberta Sustainable Resource Development, Karelian Bear Shepherding Institute of Canada, Canmore, Alberta.

Hopkins, J. B., Herrero, S., Shideler, R. T., Gunther, K. A., Schwartz, C. C., & Kalinowski, S. T. (2010). A proposed lexicon of terms and concepts for human–bear management in North America. Ursus, 21(2), 154-169.

Hoskins, W. P. 1975. Yellowstone Lake tributary survey project. US National Park Service, Interagency Grizzly Bear Study Team. Bozeman, Montana.

Interagency Grizzly Bear Committee (1994). Grizzly bear/motorized access management. Report of the IGBC Taskforce on Motorized Access Management. Missoula, Montana.

Jonkel C., & McMurray, N. (1978). The Pacific Northwest Trail and grizzly bears. Border Grizzly Project, Special Report, 15. University of Montana Missoula, Montana.

Jope, K. L., & Shelby, B. (1984). Hiker behavior and the outcome of interactions with grizzly bears. Leisure Sciences, 6(3), 257-270.

Jope, K. L. (1985). Implications of grizzly bear habituation to hikers. Wildlife Society Bulletin, 13(1), 32-37.

Kasworm, W. F., & Manley, T. L. (1990). Road and trail influences on grizzly bears and black bears in northwest Montana. International Conference on Bear Research & Management, 8, 79-84.

Klaver, R. W., Claar, J. J., Rockwell, D. B., Mays, H. R. & Acevedo, C. F. (1986). Grizzly bears, insects, and people: bear management in the McDonald Peak region, Montana. Pages 204-211 in Proceedings: Grizzly Bear Habitat Symosium.

Kasworm , W. F., Radant, T. G., Tesiberg, J. E., Welander, A., Proctor, M., & Cooley, H. (2018). Cabinet-Yaak Recovery Area 2017 research and monitoring progress report. US Fish & Wildlife Service, Missoula, Montana.

Kendell, K. C. (1983). Trends in grizzly/human interactions in Glacier National Park, Montana. US Park Service, Glacier National Park, Research Division, West Glacier, Montana.

Kendall, K. C., Macleod, A. C., Boyd, K. L., Boulanger, J., Royle, J. A., Kasworm, W. F., ... & Graves, T. A. (2016). Density, distribution, and genetic structure of grizzly bears in the Cabinet-Yaak Ecosystem. The Journal of Wildlife Management, 80(2), 314-331.

Leonard, R. D., Breneman, R., & Frey, R. (1990). A case history of grizzly bear management in the Slims River area, Kluane National Park Reserve, Yukon. International Conference on Bear Research & Management, 8, 113-123.

Leawell, D. M. (2000). Vegetation and process of the Kootenai National Forest. Ph.D. Dissertation, University of Montana, Missoula, Montana.

Linden, T. H. (2018). The good, the bad and the grizzly – assessing human impact on grizzly bears (Ursus arctos horribilis) at army cutworm moth (Euxoa auxiliaris) aggregation sites in the Shoshone National Forest, Wyoming. M.S. Thesis, Norwegian University of Life Sciences, Ås, Norway.

Mace, R. D., & Waller, J. S. (1996). Grizzly bear distribution and human conflicts in Jewel Basin Hiking Area, Swan Mountains, Montana. Wildlife Society Bulletin, 24(3), 461-467.

MacHutchon, A. G., Himmer, S., Davis, H., & Gallagher, M. (1998). Temporal and spatial activity patterns among coastal bear populations. Ursus, 10, 539-546.

MacHutchon, A. G. (2014). Human-bear interaction risk assessment for the July 2014 Moose-Wilson Corridor Management Plan alternatives. US National Park Service, Grand Teton National Park, contract report. Moose, Wyoming.

Marshall, S. M. (2008). Behavioural effects of viewing and social dynamics of grizzly bears along the Fishing Branch River, Yukon. Simon Fraser University, Burnaby, British Columbia.

Mattson, D. J., Knight, R. R., & Blanchard, B. M. (1987). The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. International Conference on Bear Research & Management, 7, 259-273.

Mattson, D. J. (1990). Human impacts on bear habitat use. International Conference on Bear Research & Mattson, 8, 33-56.

Mattson, D. J., & Merrill, T. (2004). A model-based appraisal of habitat conditions for grizzly bears in the Cabinet–Yaak region of Montana and Idaho. Ursus, 15(1), 76-90.

Mattson, D. J. (2019). Effects of the proposed Black Ram Project on Yaak grizzly bears: comments on the Black Ram Environmental Assessment. Grizzly Bear Recovery Project Report. Livingston, Montana.

McArthur-Jope, K. L. (1983). Habituation of grizzly bears to people: a hypothesis. International Conference of Bear Research & Management, 5, 322-327.

McLellan, B. N., & Shackleton, D. M. (1988). Grizzly bears and resource-extraction industries: effects of roads on behaviour, habitat use and demography. Journal of Applied Ecology, 25(2), 451-460.

McLellan, B. N., & Shackleton, D. M. (1989). Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin, 17(3), 269-274.

McLellan, B.N. & Hovey, F. W. (1995). The diet of grizzly bears in the Flathead River drainage of southeastern British Columbia. Canadian Journal of Zoology, 73,704-712.

McLellan, B.N. (2015). Some mechanisms underlying variation on vital rates on grizzly bear in an industrial landscape. The Journal of Wildlife Management, 79, 749-765.

Miller, S. D., White, G. C., Sellers, R. A., Reynolds, H. V., Schoen, J. W., Titus, K., ... & Schwartz, C. C. (1997). Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs, 133, 1-55.

Moen, G. K., Støen, O. G., Sahlén, V., & Swenson, J. E. (2012). Behaviour of solitary adult Scandinavian brown bears (Ursus arctos) when approached by humans on foot. PLoS One, 7(2), e31699.

Moen, G. K., Ordiz, A., Kindberg, J., Swenson, J. E., Sundell, J., & Støen, O. G. (2019). Behavioral reactions of brown bears to approaching humans in Fennoscandia. Écoscience, 26(1), 23-33.

Mowat, G., Heard, D. C., & Schwarz, C. J. (2013). Predicting grizzly bear density in western North America. PLoS One, 8(12), e82757.

Mueller, C., Herrero, S., & Gibeau, M. L. (2004). Distribution of subadult grizzly bears in relation to human development in the Bow River Watershed, Alberta. Ursus, 15(1), 35-48.

Mysterud, I. (1983). Characteristics of summer beds of European brown bears in Norway. International Conference on Bear Research & Management, 5, 208-222.

Nadeau, M. S. (1987). Habitats, trails, and campground situations associated with grizzly-human confrontations in Glacier National Park, Montana. M.S. Thesis, University of Montana, Missoula, Montana.

Nadeau, M. S. (1989). Movements of grizzly bears near a campground in Glacier National Park. Pages 27-33 in Proceedings: Bear-People Conflicts: A Symposium on Management Strategies. Northwest Territories Department of Renewable Resources, Yellowknife, Northwest Territories, Canada.

Naves, J., Fernández-Gil, A., & Delibes, M. (2001). Effects of recreation activities on a brown bear family group in Spain. Ursus, 12, 135-139.

Nevin, O. T., & Gilbert, B. K. (2005a). Perceived risk, displacement and refuging in brown bears: positive impacts of ecotourism?. Biological Conservation, 121(4), 611-622.

Nevin, O. T., & Gilbert, B. K. (2005b). Measuring the cost of risk avoidance in brown bears: further evidence of positive impacts of ecotourism. Biological Conservation, 123(4), 453-460.

Novikov, G. A., Airapet'yants, A. E., Pukinsky, Yu. B., Timofeeva, E. K., & Fokin, I. M. (1969). Buryi medved v Leningradskoi Oblasti. Byulleten Noskovskogo Obshchestva Ispytatelei Prirody, Otdel Biologii, 74(3), 102-117.

Olson, T. L., & Gilbert, B. K. (1994). Variable impacts of people on brown bear use of an Alaskan river. International Conference on Bear Research & Management, 9, 97-106.

Olson, T. L., Gilbert, B. K., & Squibb, R. C. (1997). The effects of increasing human activity on brown bear use of an Alaskan river. Biological Conservation, 82(1), 95-99.

Olson, T. L., Squibb, R. C., & Gilbert, B. K. (1998). Brown bear diurnal activity and human use: a comparison of two salmon streams. Ursus, 10, 547-555.

Ordiz, A., Støen, O. G., Sæbø, S., Kindberg, J., Delibes, M., & Swenson, J. E. (2012). Do bears know they are being hunted?. Biological Conservation, 152, 21-28.

Ordiz, A., Støen, O. G., Sæbø, S., Sahlén, V., Pedersen, B. E., Kindberg, J., & Swenson, J. E. (2013). Lasting behavioural responses of brown bears to experimental encounters with humans. Journal of Applied Ecology, 50(2), 306-314.

Ordiz, A., Sæbø, S., Kindberg, J., Swenson, J. E., & Støen, O. G. (2017). Seasonality and human disturbance alter brown bear activity patterns: implications for circumpolar carnivore conservation?. Animal Conservation, 20(1), 51-60.

Ordiz, A., Moen, G. K., Sæbø, S., Stenset, N., Swenson, J. E., & Støen, O. G. (2019). Habituation, sensitization, or consistent behavioral responses? Brown bear responses after repeated approaches by humans on foot. Biological Conservation, 232, 228-237.

Outdoor Foundation (2017). Outdoor recreation participation: topline report 2017. The Outdoor Foundation, Washington, D.C.

Pitts, A. (2001). Effects of wildlife viewing on the behaviour fo grizzly bear (Ursus arctos) in the Khutseymateen (K'tzim-a-deen) Grizzly Bear Sanctuary, British Columbia. M.S. Thesis, University of British Columbia, Vancouver, British Columbia.

Proctor, M. F., Paetkau, D., Mclellan, B. N., Stenhouse, G. B., Kendall, K. C., Mace, R. D., ... & Wakkinen, W. L. (2012). Population fragmentation and inter-ecosystem movements of grizzly bears in western Canada and the northern United States. Wildlife Monographs, 180(1), 1-46.

Proctor, M. F., Nielsen, S. E., Kasworm, W. F., Servheen, C., Radandt, T. G., Machutchon, A. G., & Boyce, M. S. (2015). Grizzly bear connectivity mapping in the Canada–United States trans-border region. The Journal of Wildlife Management, 79(4), 544-558.

Proctor, M., Lamb, C., & MacHutchon, G. (2017). The grizzly dance between berries and bullets: relationships among bottom-up food resources and top-down mortality risk on grizzly bear populations in southeast British Columbia. Trans-border Grizzly Bear Project, Birchdale Ecological, Kaslo, British Columbia.

Proctor, M. F., Kasworm, W. F., Annis, K. M., MacHutchon, A. G., Teisberg, J. E., Radandt, T. G., & Servheen, C. (2018). Conservation of threatened Canada-USA trans-border grizzly bears linked to comprehensive conflict reduction. Human–Wildlife Interactions, 12(3), 348-372.

Quinn, M., & Chernoff, G. (2010). Mountain biking: a review of ecological effects. A literature review for Parks Canada—National Office (Visitor Experience Branch): final report. Miistakis Institute, University of Calgary, Calgary, Alberta.

Rankin, C. H., Abrams, T., Barry, R. J., Bhatnagar, S., Clayton, D. F., Colombo, J., ... & McSweeney, F. K. (2009). Habituation revisited: an updated and revised description of the behavioral characteristics of habituation. Neurobiology of Learning & Memory, 92(2), 135-138.

Revenko, I. A. (1994). Brown bear (Ursus arctos piscator) reaction to humans on Kamchatka. International Conference on Bear Research & Management, 9, 107-108.

Rode, K. D., Farley, S. D., & Robbins, C. T. (2006a). Behavioral responses of brown bears mediate nutritional effects of experimentally introduced tourism. Biological Conservation, 133(1), 70-80.

Rode, K. D., Farley, S. D., & Robbins, C. T. (2006b). Sexual dimorphism, reproductive strategy, and human activities determine resource use by brown bears. Ecology, 87(10), 2636-2646.

Rode, K. D., Farley, S. D., Fortin, J., & Robbins, C. T. (2007). Nutritional consequences of experimentally introduced tourism in brown bears. The Journal of Wildlife Management, 71(3), 929-939.

Roever, C. L., Boyce, M. S., & Stenhouse, G. B. (2008). Grizzly bears and forestry: II: grizzly bear habitat selection and conflicts with road placement. Forest Ecology & Management, 256(6), 1262-1269.

Russell, C., & Enns, M. (2002). Grizzly heart: living without fear among the brown bears of Kamchatka. Random House, Vintage Canada, Toronto, Ontario.

Ruth, T. K., Smith, D. W., Haroldson, M. A., Buotte, P. C., Schwartz, C. C., Quigley, H. B., ... & Frey, K. (2003). Large-carnivore response to recreational big-game hunting along the Yellowstone National Park and Absaroka-Beartooth Wilderness boundary. Wildlife Society Bulletin, 31(4), 1150-1161.

Sahlén, V., Ordiz, A., Swenson, J. E., & Støen, O. G. (2015). Behavioural differences between single Scandinavian brown bears (Ursus arctos) and females with dependent young when experimentally approached by humans. PLoS One, 10(4), e0121576.

Servheen, C., Manley, T., Mucklow-Starling, D., Jacobs, A., Waller, J. (2017). Board of review recommendations related to mountain biker safety in bear habitat based on the fatality of Mr. Brad Treat on June 29, 2016. University of Montana, Missoula, Montana.

Schleyer, B. O. (1983). Activity patterns of grizzly bears in the Yellowstone ecosystem and their reproductive behavior, predation and the use of carrion. M.S. Thesis, Montana State University, Bozeman, Montana.

Schleyer, B. O., Jonkel, J. J., Rhoades, K. G., & Dunbar, D. M. (1984). The effects of nonmotorized recreation on grizzly bear behavior and habitat use. US Park Service, Interagency Grizzly Bear Study Team, Bozeman, Montana.

Schmor, M. R. (1999). An exploration into bear deterrents, as related to mountain biking, and the design of an ultrasonic bear warning device. M.S. Thesis, University of Calgary, Calgary, Alberta.

Schwartz, C. C., Miller, S. D. & Haroldson, M. A. (2003). Grizzly bear. Pages 556-586 in Feldhamer, G. A., Thompson, B. C., & Chapman, J. A. (eds.). Wild mammals of North America: biology, management, and conservation. Second edition. Johns Hopkins University Press, Baltimore, Maryland.

Servheen, C., Haroldson, M., Gunther, K., Barber, K., Brucino, M., Cherry, M.,…Summerfield, B. (2004). Yellowstone mortality and conflicts reduction report. US Fish & Wildlife Service, Missoula, Montana.

Servheen, C., Haroldson, M., Schwartz, C., Brucino, M., Cain, S., Frey, K.,…Claar, J. (2009). Yellowstone mortality and conflicts reduction report. US Fish & Wildlife Service, Missoula, Montana.

Skuban, M., Find'o, S., & Kajba, M. (2017). Bears napping nearby: daybed selection by brown bears (Ursus arctos) in a human-dominated landscape. Canadian Journal of Zoology, 96(1), 1-11.

Smith, T. S. (2002). Effects of human activity on brown bear use of the Kulik River, Alaska. Ursus, 13, 257-267.

Smith, T. S., & Johnson, B. A. (2004). Modeling the effects of human activity on Katmai brown bears (Ursus arctos) through the use of survival analysis. Arctic, 57(2), 160-165.

Smith, T. S., Herrero, S. & DeBruyn, T. D. (2005). Alaskan brown bears, humans, and habituation. Ursus, 16(1), 1-10.

Smith, T. S., & Herrero, S. (2018). Human–bear conflict in Alaska: 1880–2015. Wildlife Society Bulletin, 42(2), 254-263.

Steyaert, S. M. J. G., Leclerc, M., Pelletier, F., Kindberg, J., Brunberg, S., Swenson, J. E., & Zedrosser, A. (2016). Human shields mediate sexual conflict in a top predator. Proceedings of the Royal Society B: Biological Sciences, 283(1833), 20160906.

Støen, O. G., Ordiz, A., Sahlén, V., Arnemo, J. M., Sæbø, S., Mattsing, G., ... & Swenson, J. E. (2018). Brown bear (Ursus arctos) attacks resulting in human casualties in Scandinavia 1977–2016: management implications and recommendations. PloS One, 13(5), e0196876.

Stonorov, D., & Stokes, A. W. (1972). Social behavior of the Alaska brown bear. International Conference on Bear Research & Management, 2, 232-242.

Stringham, S. F., & Rogers, L. L. (2017). Fear of Humans by Bears and Other Animals (Anthropophobia): How Much is Natural?. Journal of Behavior, 2(2), 1009.

Suring, L. H., Farley, S. D., Hilderbrand, G. V., Goldstein, M. I., Howlin, S., & Erickson, W. P. (2006). Patterns of landscape use by female brown bears on the Kenai Peninsula, Alaska. The Journal of Wildlife Management, 70(6), 1580-1587.

Toman, T., Gingery, M., Servheen, C., & Gladen, J. (1991). Draft report to Yellowstone Ecosystem Grizzly Bear Subcommittee regarding recommended actions to reduce grizzly/hunter conflicts. Wyoming Game & Fish Department, Cheyenne, Wyoming.

US Forest Service & National Park Service (1980). Pacific Northwest Trail: a report based on a joint study by the Forest Service and National Park Service. US Forest Service, Northern Region, Missoula, Montana.

US Forest Service (2019). Black Ram Environmental Assessment. US Forest Service, Kootenai National Forest, Three Rivers Ranger District, Troy, Montana.

Van Dyke, C. (2003). Human and brown bear use of Eva Creek: a site assessment. Alaska Department of Fish & Game, Division of Wildlife Conservation, Anchorage, Alaska.

Warner, S. H. (1987). Visitor impact on brown bears, Admiralty Island, Alaska. International Conference on Bear Research & Management, 7, 377-381.

Wheat, R. E., & Wilmers, C. C. (2016). Habituation reverses fear-based ecological effects in brown bears (Ursus arctos). Ecosphere, 7(7), e01408.

White Jr, D., Kendall, K. C., & Picton, H. D. (1999). Potential energetic effects of mountain climbers on foraging grizzly bears. Wildlife Society Bulletin, 27, 146-151.

Wilker, G. A., & Barnes Jr, V. G. (1998). Responses of brown bears to human activities at O'Malley River, Kodiak Island, Alaska. Ursus, 10, 557-561.

Zunino, F. (1981). Dilemmna of the Abruzzo bears. Oryx, 16, 153-156.

Effects of Pedestrians on Grizzly Bears

An Evaluation of the Effects of Hikers, Hunters, Photographers, Campers, and Watchers

Report GBRP-2019-3

2019

The Grizzly Bear Recovery Project

P.O. Box 2406,
Livingston,
Montana