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Brown bear and human recreational use of trails in Anchorage, Alaska

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Abstract: Anchorage, Alaska, has 301,000 human residents and hundreds of thousands of visitors each year. Anchorage also supports a viable population of brown bears (*Ursus arctos*). As a result, human–bear encounters are common. We used camera traps to monitor recreational trails near salmon spawning streams at 3 study sites during the summers of 2009 to 2012 to better understand daily and seasonal activity patterns of bears and humans on these trails. The more remote study sites had the least human activity and the most bear activity. Human–bear encounters were most likely to occur from July through early September due to a higher degree of overlap between human and bear activity during this timeframe. Most brown bears at our study sites appeared to have adopted a crepuscular and nocturnal activity pattern, which was more pronounced at the site with the most human use. More people used trails Friday through Sunday, while there was no difference in bear activity among other days of week. Recreational activities and user groups differed among sites. Based on our data, areas should be assessed individually to mitigate adverse human–bear encounters. However, a potential solution for avoiding dangerous bear encounters is to restrict human access or types of recreational activity. When human access is controlled in bear habitat, distribution of visitors becomes spatially and temporally more predictable, allowing bears an opportunity to adjust activity patterns to avoid people while still using the resource.

Key words: brown bears, human–bear conflicts, recreational activity, remote cameras, *Ursus arctos*

Brown (grizzly) bears (*Ursus arctos*) occasionally attack people in wild areas of the western United States and Canada (Herrero 2002). Although attacks are rare (McMillion 1998), many people have a visceral fear of being injured by a bear (McMillion 1998, Gunther et al. 2004). Regardless, brown bears are rarely considered a public safety threat in or near urban areas (Mattson 1990), as they are not often found near human population centers. One exception is the Municipality of Anchorage, Alaska, (MOA; 61^{o} 13′ N, 149o 52′ W; Figure 1), which supports a viable brown bear population and is, therefore, unique among large North American cities.

The MOA, consisting of a metropolitan area and several satellite communities, has approximately 301,000 residents (U. S. Census Bureau 2013) and hundreds of thousands of visitors every summer. Most brown bear habitat within the MOA is located in Chugach State Park, a 2,005-km^2 natural area with an estimated 1.3 million visitors per year (Alaska Department of Natural Resources 2009), and Joint Base Elmendorf-Richardson, a military reservation encompassing 340 km^2 of mostly natural habitat (Figure 1). At least 60 brown bears inhabit the park and adjacent areas in the municipality (Alaska Department of Fish and Game, unpublished data).

There are 160 km of salmon- (*Onchorhynchus* spp.) spawning streams in the MOA. Where available, salmon are a critical food resource for brown bears (Hilderbrand et al. 1999). Stable isotope analysis of hair from radio-collared brown bears in the Anchorage area revealed that bears. Frequenting anadromous streams had a diet that was 37 ± 19% salmon (range 28 to 74%; Farley et al. 2008). Because many stretches of local anadromous streams are deep or obscured by suspended glacial silt, suitable foraging areas for bears are limited, and most of these foraging areas are located in or adjacent to developed areas of the municipality. As a result, brown bears spend substantial periods in late summer and fall foraging for salmon and other foods in lowland areas (Farley et al. 2008) where they often encounter people.

Several hundred thousand people live and recreate in areas frequented by brown bears within the MOA; however, few maulings have been reported. From 1908 to 2014, 22 people

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have been reported injured and two killed by brown bears within the MOA. Details and exact locations of maulings reported prior to 1991 are unclear (n = 3, Kaniut 1990). However, most maulings, including 19 injuries and 2 fatalities, occurred after 1990, and all but one of these happened on public property. In the last decade, maulings have been closer to developed areas than in the past (Figure 2). The 9 maulings prior to 2005 were in remote areas or near small, isolated communities, whereas ten of the 15 maulings since 2005 were on recreational trails near the MOA and Eagle River. In addition, the number of women victims of bear attacks has increased (six out of seven since 2005), and the activities of the victims have changed in recent years. Whereas earlier victims were hiking or camping when attacked, 5 of the last 15 mauling victims were running, and two were biking. Proximity to salmon spawning streams also appears to be a factor in attacks; eleven of the 21 maulings since 1990 have occurred within 100 m of a salmon spawning stream. Further, numerous additional people have been charged or chased by brown bears, and most of these attacks have also been on trails close to spawning streams (R. Sinnott and J. A. Coltrane, Alaska Department of Fish and Game, unpublished data).

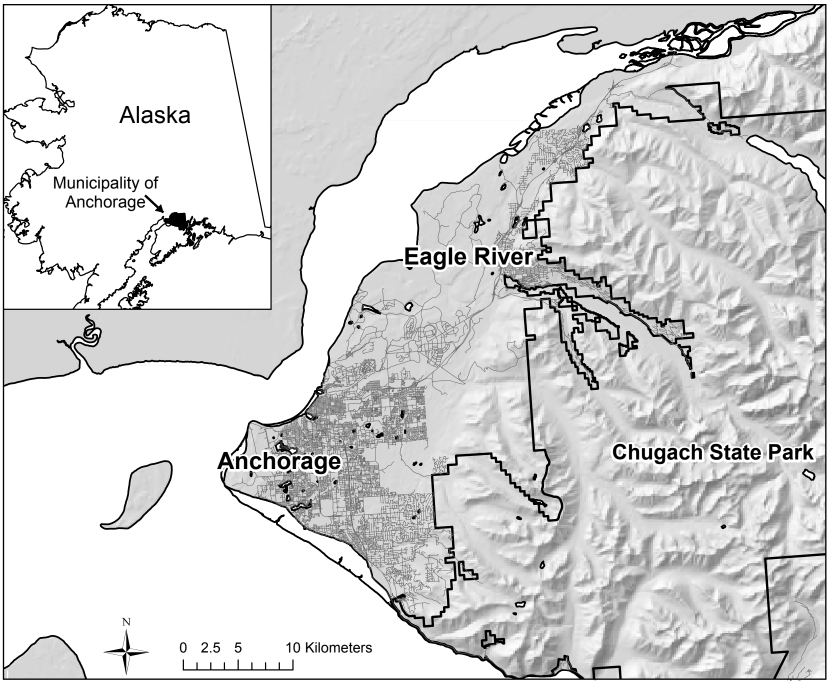

Figure 1. The Municipality of Anchorage, Alaska (61° 13' N, 149° 52' W).

The Anchorage area has nearly 300 km of paved and unpaved municipal trails, 426 km maintained hiking trails in Chugach State Park, and hundreds of kilometers of unofficial, unmaintained trails. Many residents use local trails in summer for hiking, running, and mountain biking, and as the city grows, the demand for more trails increases (J. Rodda, Anchorage Parks and Recreation, personal communication). The Alaska Department of Fish and Game has recommended that public agencies avoid building or improving trails in areas with seasonal concentrations of brown bears. Information on bear and human use on existing trails and at potential new trail locations could be used by wildlife and land management agencies to mitigate and avoid potential human–bear conflicts. To better understand daily and seasonal activity patterns of bears and humans on trails in the MOA, we monitored trails near spawning streams with camera traps during the summers of 2009 to 2012.

Study area

This study was conducted in the MOA, the largest city in Alaska (Figure 1). The largest Anchorage communities are connected by the Glenn Highway, a 4-lane divided highway with an average daily traffic volume of 49,000 to 52,000 vehicles from 2004 to 2008 (Alaska Department of Transportation and Public Facilities 2011), and all of the communities within the MOA border Chugach State Park. Brown bear habitat in the Anchorage area includes alpine tundra and subalpine shrub thickets dominated by alder (*Alnus* sp.). At lower elevations, most bear habitat consists of closed spruce-hardwood forests dominated by white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*) and quaking aspen (*P. tremuloides*) and open low-growing spruce forests, that are dominated by black spruce (*P. mariana*, Viereck and Little 1972).

We compared human and brown bear use at 3 study sites (Meadow Creek, South Fork of Campbell Creek, and South Fork of Eagle River) in the MOA in 2009 to 2012 (Figure 3). Each site included unpaved human recreational trails adjacent to salmon spawning streams and was located in closed spruce-hardwood forest dominated by white spruce and balsam poplar. There have been reports of bear attacks and other adverse encounters with brown bears at each of these sites. We monitored trails that had varying levels of human activity and known use by brown bears at each site.

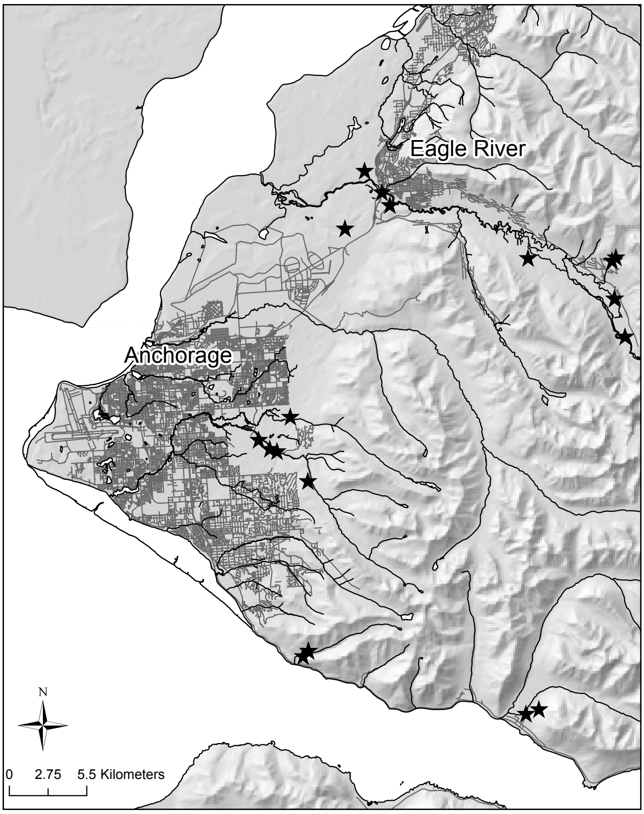

Figure 2. Location of brown bear attacks in the Municipality of Anchorage, Alaska (1991 to 2014).

The first study site was located at Meadow Creek, which provides spawning habitat for chinook (*Oncorhynchus tshawytscha*) and humpback (*O. gorbuscha*) salmon for approximately 600 m above its confluence with Eagle River (Figure 3A). The lower 100 m of Meadow Creek is in Chugach State Park, and the remainder traverses private property. Meadow Creek is surrounded by a network of unmaintained trails. This location was chosen as a study site because it is adjacent to a neighborhood, the trails have relatively little human use, and the creek supports a small run of salmon (<200 chinooks and humpbacks) known to attract brown bears. The creek is adjacent to the Glenn Highway underpasses that provide a corridor between bear habitat in Chugach State Park and Joint Base Elmendorf-Richardson. A larger trailhead and connector trail to existing Chugach State Park trails has been proposed at this site.

The second study site was located at the South Fork of Campbell Creek, which travels through the center of the MOA (Figure 3B). The upstream extent of salmon spawning is within Far North Bicentennial Park, a 16.2-km^2 municipal park with >1 million visitors annually (Dowl HKM 2009) that lies between Chugach State Park and the eastern edge of the metropolitan area. Chinook, humpback, sockeye (*O. nerka)*, and coho (*O. kisutch*) salmon spawn in the creek. Brown bears seldom follow the creek downstream into the metropolitan area, but ≥20 bears frequent the portion in Far North Bicentennial Park (Farley et al. 2008). This site was chosen because it is heavily used by people, although it was >1 km from a trailhead or any houses; trails are maintained by the MOA and are popular among recreationists. The creek supports runs of salmon that are known to attract brown bears. New trails have been built and others upgraded in Far North Bicentennial Park in the past decade and there is demand for more.

The third study site was located along the South Fork of Eagle River, which is

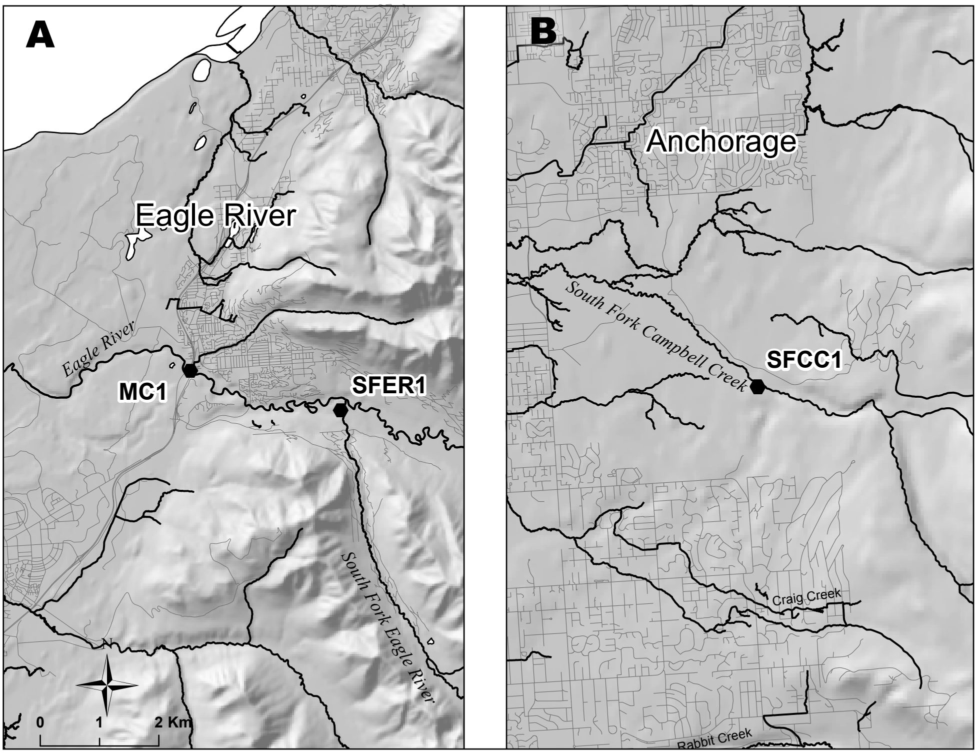

Figure 3. Locations of remote cameras adjacent to salmon spawning creeks in Anchorage, Alaska: (A) MC1 and SFER1; (B) SFCC1.

approximately 5.5 km upstream of the Meadow Creek confluence and is located in Chugach State Park and on private property (Figure 3A). Only the lower 1.3 km of the stream provides spawning habitat for chinook and humpback salmon. This study site was chosen because it is >1 km from houses, nearby trails are not maintained and have relatively little human use. The creek, which supports a run of several hundred spawning salmon, is known to attract brown bears.

Methods

Remote cameras

Camera models. We used remote digital trail cameras (RECONYX PC90HO RapidFire™ Professional High Output and PC900 HyperFire™ Professional High Output Covert IR, RECONYX Inc., Holmen, Wis.) to monitor bear and human activity on trails. RECONYX trail cameras use a passive infrared system, whereby the camera is triggered by detection of motion and changes in ambient infrared. These cameras have been shown to detect virtually every visit of individual mammals and birds (Dixon et al. 2009). Although no camera's passive infrared sensor is perfect (Hughson et al. 2010), RECONYX digital trail cameras typically perform well compared to other brands (Duke and Quinn 2008, Kelly and Holub 2008, Hughson et al. 2010). Both bears and humans have high detection rates with passive infrared trail cameras (Gompper et al. 2006).

The PC90H0 cameras had a trigger speed of 0.2 seconds and could record ≤1 image per second. Images were 3.1 megapixels and recorded in color during the day and monochrome at night. The passive infrared motion detector covered a 40° field of view and was capable of triggering the camera at distances of ≤30.5 m. A covert infrared flash illuminated a distance of ≤15 m at night. The PC900 cameras had the same resolution and trigger speed, but could record ≤2 images/second. The camera's no-glow covert infrared flash illuminated ≤15 m at night.

Camera settings and placement. Cameras were fastened to trees approximately 3 to 4 m above the ground and were positioned to capture subjects within 10 to 15 m. We used the aiming function to ensure that each camera was properly situated to capture bear and human activity. Cameras were programmed to fire 3 or 5 times at 1-second intervals when triggered by movement within the detection zone. We used the high sensitivity setting for the motion sensor with no delay between triggering events. Cameras captured images 24 hours per day, and each image was stamped with the date and time of acquisition. We used the "night mode" default setting, which RECONYX recommended as the best combination to balance image quality, shutter speed, and flash range. Image quality allowed for monitoring trails during both daylight and darkness. We visited the cameras weekly to ensure that they were functioning properly, switch storage cards and, if necessary, replace batteries.

Camera locations. At each study site, we placed the primary camera on the targeted trail (Figure 3). Primary camera locations were not chosen randomly; instead, we attempted to record maximum trail activity by both bears and people. At the Meadow Creek study site, the primary trail camera (MC1) was located on an unmaintained trail on the north bank of Eagle River between the 2 highway overpasses and 55 m from the mouth of Meadow Creek. This was one of the most definitive trails in the area, and it captured more bears and people moving under the overpasses on the north bank of Eagle River. The primary trail camera at the South Fork of Campbell Creek study site (SFCC1) was located on Rover's Run, a maintained trail that parallels the stream for several kilometers. At the South Fork of Eagle River, the primary trail camera (SFER1) was located where the Lower Eagle River Trail crossed the stream, about 320 m upstream from where the streams joined Eagle River. The

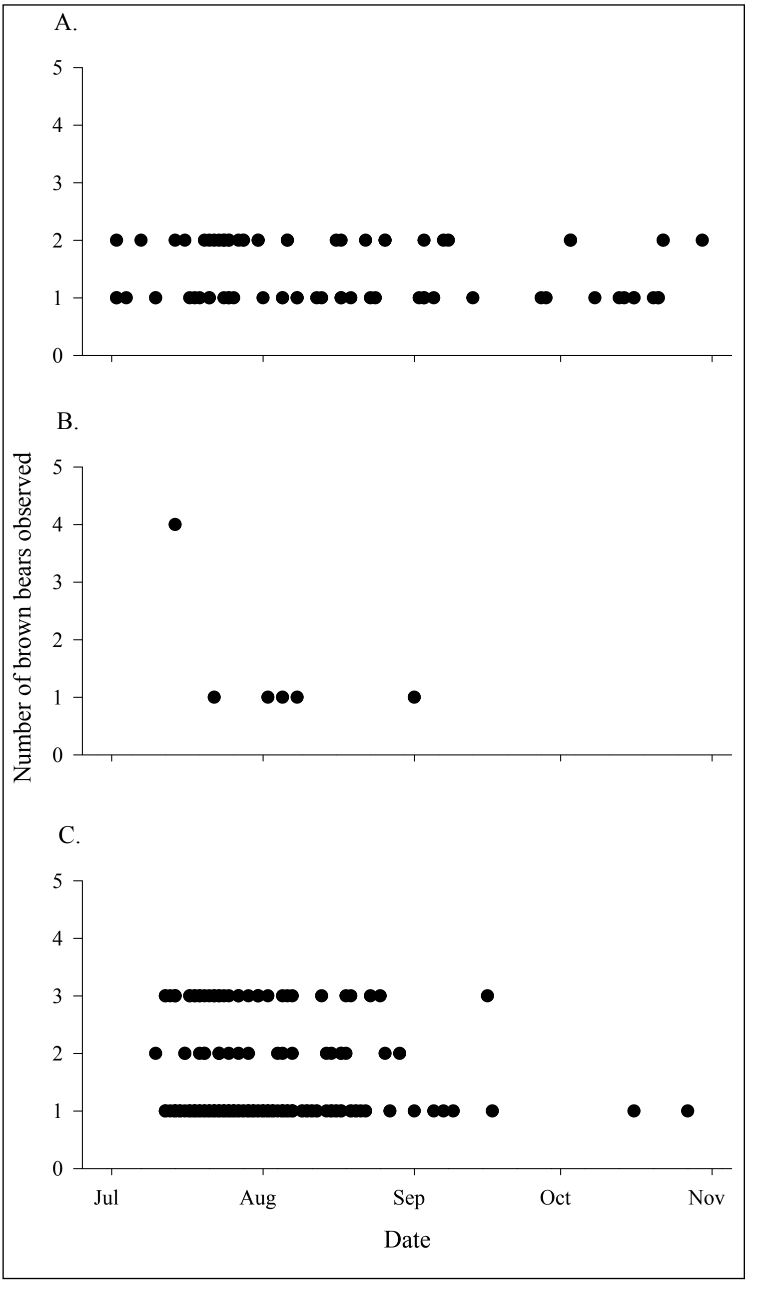

Figure 4. Numbers of brown bears recorded by remote cameras placed along recreational trails adjacent to salmon spawning streams in the Municipality of Anchorage, Alaska (2009 to 2012): (A) Meadow Creek study site (MC1; 2009 to 2012); (B) South Fork Campbell Creek (SFCC1; 2010); and (C) South Fork Eagle River study site (SFER1; 2009 to 2010).

Table 1. Camera deployment and recorded bear and human activity at recreational trails adjacent to salmon creeks in the Municipality of Anchorage, Alaska 2009 to 2012.

	People use								
Study site	Adult male	Adult female	Teen male	Teen female	Child	Total people	Total groups	Average group size (± SD)	People/ day
MC1	16	6	6	2	2	32	21	1.52 ± 0.87	0.26
	44	20		2	3	69	45	1.53 ± 0.76	0.56
	34	24	10	0	0	68	43	1.58 ± 0.63	0.55
	30	18	3	0	4	55	37	1.49 ± 0.80	0.52
SFER1	55	1	0	0	1	57	48	1.19 ± 0.49	0.50
	103	17	2	0	5	127	86	1.48 ± 0.70	1.03
SFCC1	1370	668	22	18	27	2105	1264	1.65 ± 1.27	17.11

	Brown bear use							
Study site	Adult male	Adult female	2-year-old	1-year-old	Cub of year	Total[a]	Bear/day	People:bear index
MC1	0	16	0	12	0	28	0.24	0.94
	0	28	5	0	0	33	0.27	0.48
	0	13	0	3	9	25	0.20	0.37
	0	10	8	1	0	19	0.18	0.35
SFER1	62	8	8	64	16	158	1.52	3.04
	38	14	4	7	2	65	0.86	0.83
SFCC1	2	1	1	4	0	8	0.07	0.004

[a] Includes bears of unknown sex or age

camera was positioned on the west bank and aimed at the unmaintained trail. The detection area included a large log that spanned the creek, allowing people and wildlife to cross.

Trail use

For each human observation, we recorded age, sex category, and number of people in a group, as well as their activity. We subjectively classified trail users as children (0 to 12 years of age), teenagers (approximately 13 to 19 years of age), and adults. Gender of teenagers and adults was relatively easy to identify from the photos, although fast-moving subjects were slightly blurred and outerwear and useful details were obscured in a small number of photos. We classified activities as walking, running, biking, fishing (carrying a rod or other fishing gear), horseback riding, and working. We counted an individual person making a round trip as 2 separate camera captures, unless the person returned within 5 minutes or turned around below the camera, because the number of passes by individual people was more important for measuring the risk of a bear attack than the number of individuals observed at a location. People carrying leashes were assumed to be accompanied by ≤1 dog. We also noted if people were carrying a bear deterrent, such as a firearm or bear spray. In addition, we noted when people were actively using a cell phone. While cell phones often are considered a safety item, we considered them a hazard when we observed them actively being used. We assumed that texting and talking on the phone made users less aware of their surroundings.

For each bear observation, we noted its sex, age (cub, subadult, and adult), and total number of bears. While we were unable to ascertain the sex of many bears, adult males and sows with cubs were easily identified. Most other bears were classified as adult or subadult bears of unknown sex. We did not classify what activity bears were engaged in.

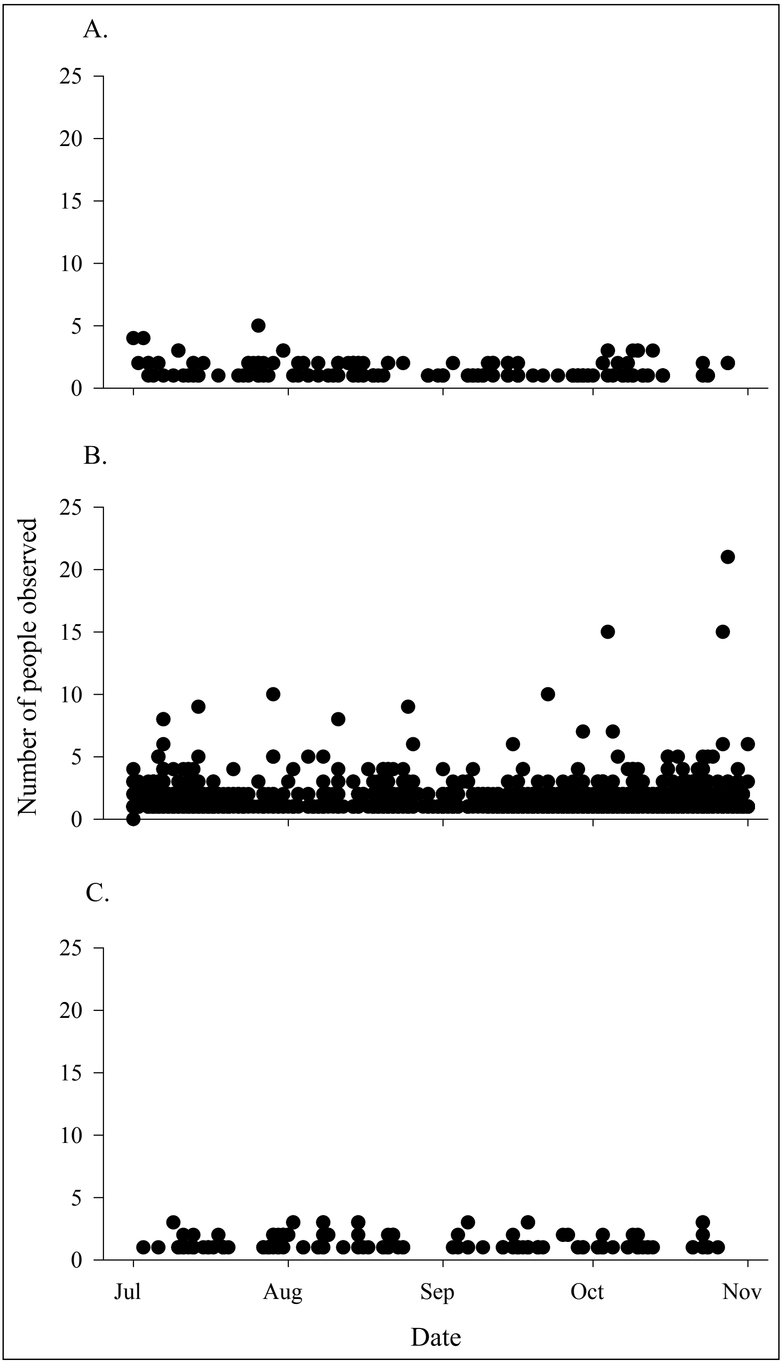

Figure 5. Numbers of people recorded by remote cameras placed along recreational trails adjacent to salmon spawning streams in the Municipality of Anchorage, Alaska (2009 to 2012): (A) Meadow Creek study site (MC1; 2009-2012); (B) South Fork Campbell Creek (SFCC1; 2010); and (C) South Fork Eagle River study site (SFER1; 2009 to 2010).

Statistics

Zero inflated negative binomial regression was used to determine variables most predictive of level of bear activity. This distribution was selected after assessing model fit and dispersion for poisson, zero inflated poisson, negative binomial, and zero inflated negative binomial regression. A set of 17 *a priori* candidate models was developed that included biologically relevant combinations of year, study site, time of day, and number of people observed. Correlated variables ($P > 0.05$) were not permitted to enter the same model. Akaike's Information Criterion corrected for small sample size (AIC_c) was used to rank the model(s), where models were considered plausible if $\Delta AIC_c < 2$ (Burnham and Anderson 2002). Additionally, we compared human and bear activity across days of the week for each site using a Pearson's chi-squared test (χ^2). We reported standard deviations (±SD) of means.

Results

The 3 study sites were monitored for bear and human activity during the summers of 2009 to 2012 for a total of 1,115 trap days (Table 1). In 2009, MC1 and SFER1 were deployed for 299 trap days; in 2010, MC1, SFER1, and SFCC1 were deployed for 559 trap days; and in 2011 and 2012, MC1 was deployed for 126 and 131 trap days, respectively. In 2010, people tampered with, but did not destroy, SFER1 camera, and 2 cameras were stolen from

Table 2. Zero negative binomial regression models for variables predicting number of brown bears observed at trails along salmon streams in Anchorage, Alaska, 2009 to 2012.

Model	Number of parameters	ΔAIC_c [a]	AIC_{cw} [b]
Time of day + site + people	11	0	0.585881353
Time of day + site	9	1.785320683	0.239956332
Time of day + year + site + people	13	4.09081969	0.07577038
Site + people	9	5.053725705	0.046817377
Time of day + year + site	11	5.94798431	0.029937897
Site	7	8.111607874	0.010148373
Year + site + people	11	9.000358182	0.006507388
Year * site	8	10.16365632	0.003637473
Year + site	9	12.15578797	0.001343426
Time of day + people	7	43.30267183	2.32E-10
Time of day + year + people	9	46.18496928	5.48E-11
People	5	47.03630614	3.58E-11
Year + people	7	49.97072041	8.26E-12
Time of day	5	55.17173904	6.13E-13
Time of day + year	7	56.88572459	2.60E-13
Intercept	3	60.47561706	4.32E-14
Year	5	62.06133267	1.96E-14

[a]Difference between model's Akaike's Information Criterion corrected for small sample size and the lowest AIC_c value.

[b]AIC_c relative weight attributed to model.

this location in 2011. Based on presence or absence of tracks on images when the trail was muddy or snowy, we estimate that the cameras missed <1% of human trail users. There was no indication that bears ever noticed the cameras. Because we used only 3 cameras—one at each study site—we recognize that sampling bias may exist; yet, the level is unknown. However, this study is observational and not manipulative and is meant to provide insight into human and bear activity for conflict mitigation purposes. Additional cameras would be required to address specific hypotheses.

Bears were first detected by a camera on June 26, 2010, and bear activity at camera sites dropped off dramatically after September 15, 2010 (Figure 4). The latest bear sighting was recorded on October 30, 2011 (Figure 4). Cameras captured multiple visits by some bears; however, individual bears were not always identifiable, due to blurring, low-light conditions, rain or mist, and variations in shedding patterns. People used the trails throughout the duration of the study (Figure 5). To compare human and bear activity at all sites, we focused all analyses on the time period from July 1 through November 1. The following results will refer to this time period.

The level of bear activity observed was best explained by the additive models that included time of day, study site, and people (ΔAIC_c = 0, AICw = 0.59); however, the additive model that included time of day and site was also considered plausible (ΔAIC_c = 1.79, AIC_w = 0.24; Table 2). These 2 models combined explained 83% of the variation in bear activity. The number of people at each site was inversely related to the amount of bear activity (Table 1). Brown bear activity was highest at SFER1 (0.86 and 1.52 brown bears per day in 2009 and 2010, respectively), followed by MC1 (0.18 to 0.27 brown bears per day), and SFCC1 (0.07 brown

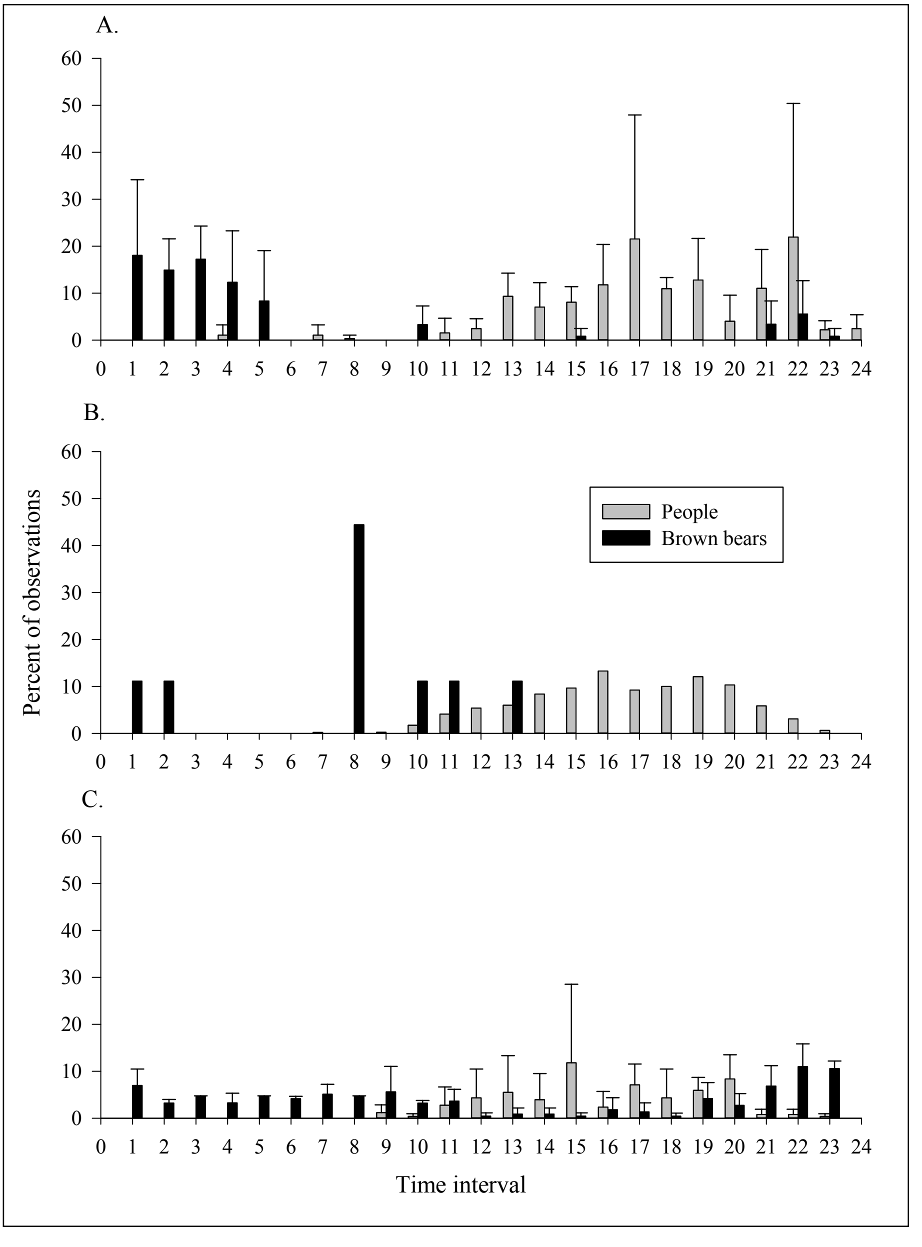

Figure 6. The distribution of humans and brown bear activity across hourly time intervals. Data were obtained using remote cameras placed along recreational trails adjacent to salmon spawning streams in the Municipality of Anchorage, Alaska (2009 to 2012): (A) Meadow Creek study site (MC1; 2009 to 2012; n = 224). Data presented include annual mean ± SD: (B) South Fork Campbell Creek (SFCC1; 2010; I = 2105); (C) South Fork Eagle River study site (SFER1; 2009 to 2010; n = 184). Data presented include annual mean ± SD.

bears per day). In comparison, the highest amount of human activity was captured at SFCC1 in 2010 (17.11 people per day), followed by SFER1 in 2010 (1.03 people per day; Table 1). Human activity was consistently lowest at MC1 and similar to SFER1 in 2009 (Table 1). The ratio of bears to people was consistently highest at SFER1 (0.83 to 3.04 bears to people) compared to the other study sites (Table 1). Few bears were captured by SFCC1.

Both time of day and people influenced bear activity at each site; bears used trails at times when fewer people were present. People were detected on trails between 0300 hours and midnight; however, most activity occurred between 1200 and 2200 hours (98% of observations, 2,763 of 2,797; Figure 6). In contrast, brown bears were observed more frequently during evening and early morning hours (91% of observations between 2000 and 1100 hours, 302 of 333 bears) when people were not as common on the trails (Figure 6). The pattern of bear activity also varied from people activity by days of the week at MC1 ($\chi^{2}6$ = 15.350, P = 0.018) and SFER1 ($\chi^{2}6$ = 34.204, $P \leq 0.001$) but not at SFCC1 ($\chi^{2}6$ = 12.490, P = 0.05; Figure 7). Bears were present throughout the week with no apparent pattern, whereas, people tended to be more active on Friday and Sunday at MC1 and on Saturday and Sunday at SFER1 (Figure 7).

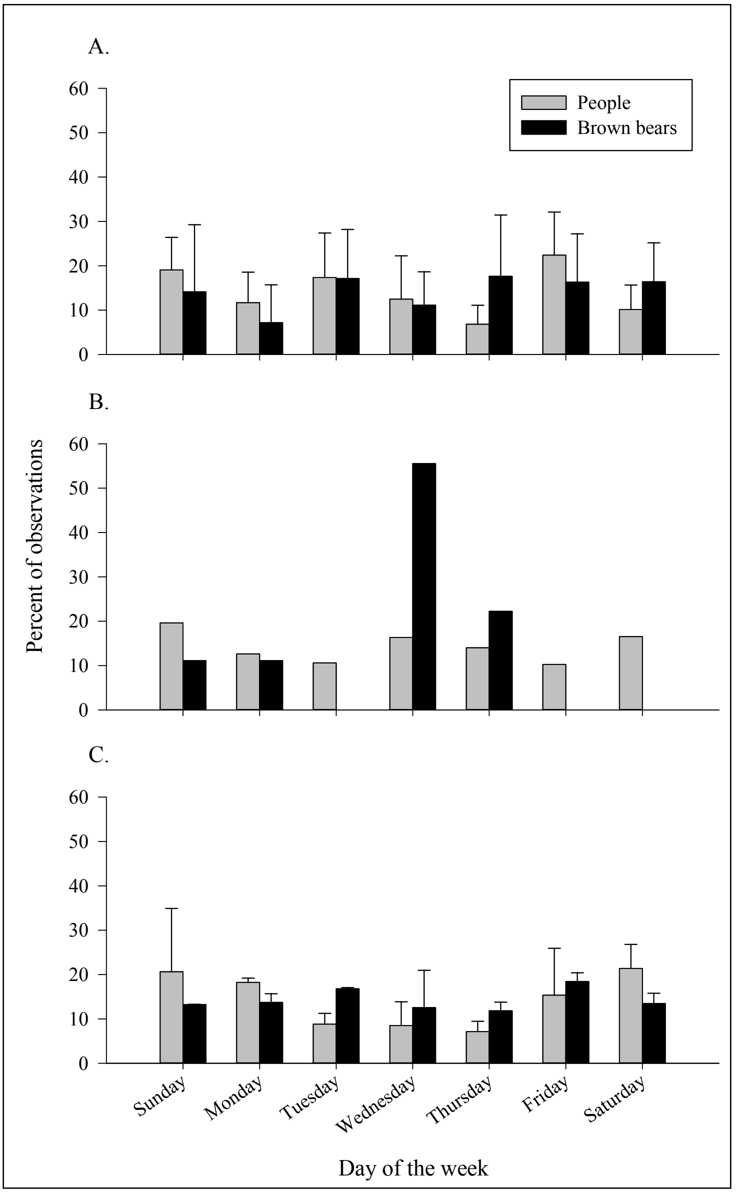

Figure 7. The distribution of human and brown bear activity across days of the week. Data were obtained using remote cameras placed along recreational trails adjacent to salmon spawning creeks in the Municipality of Anchorage, Alaska (2009 to 2012). Variation depicted by error bars is between year variation: (A) Meadow Creek study site (MC1; 2009 to 2012; n = 224). Data presented include annual mean ± SD: (B) South Fork of Campbell Creek (SFCC1; 2010; n = 2105); (C) South Fork Eagle River study site (SFER1; 2009 to 2010; n = 184). Data presented include annual mean ± SD.

It was possible to identify some individual brown bears at each study site. At least 3 distinct bears were captured at MC1 in 2009. In addition to a subadult, a sow with 1 cub returned with the same cub in 2010 and brought a subsequent cub in 2011 and 2012. During 2010, SFCC1 captured a sow with 3 cubs on 1 occasion and also an adult male and subadult bear. In contrast, at least 19 different bears, including subadults, sows with cubs, and adult males, were captured at SFER1 in 2009.

Recreational activity was recorded for 1,521 groups of people captured by the primary cameras (MC1, n = 141; SFER1, n = 134; SFCC1, n = 1246), and activities varied among trails (Figure 8). Each trail had unique patterns and frequency of use by different user groups. MC1 was visited frequently by relatively few people (average of <1 person/day; Table 1). Most of these individuals were observed regularly, and they most likely came from a nearby neighborhood. For the 4 years of observations combined at MC1, 121 of 141 groups of people were walking and 13 groups were carrying fishing gear (Figure 8). In comparison, the most common recreational activity documented on SFCC1 was mountain biking (69% of all groups), followed by walking

(15%) and running (14%; Figure 8). Horseback riding was observed only at SFCC1. Trail maintenance crews accounted for most of the "working" category, and were observed on the maintained trail (SFCC1) only. SFER1 was visited by relatively few people (average of <2 people/day; Table 1), many who were observed multiple times throughout the summer. Most groups of users were walking (52%); however, this camera location also captured a high percentage of anglers (18%) and runners (17%).

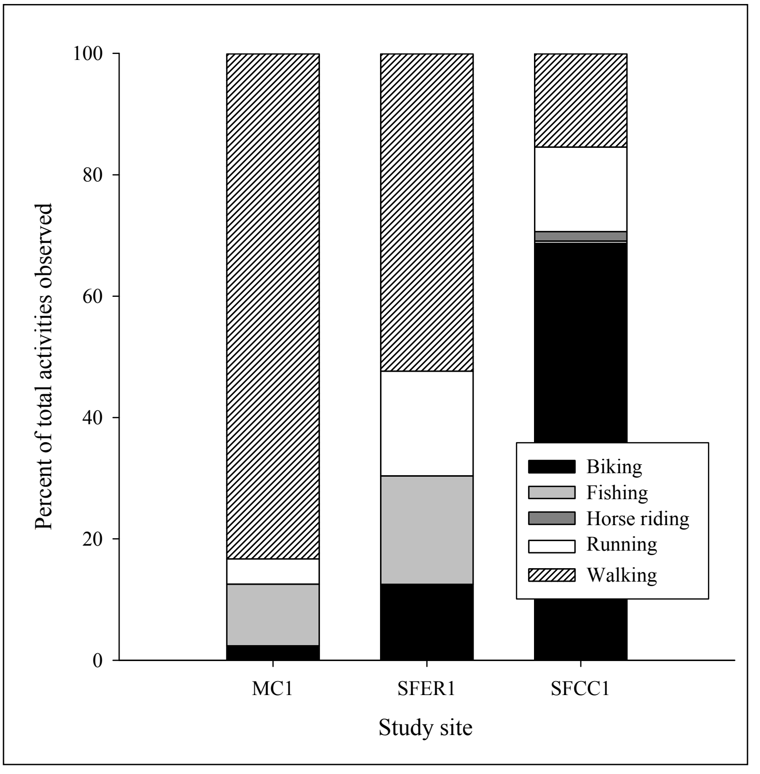

Figure 8. Human recreational activities observed at trail locations in the Municipality of Anchorage, Alaska (2009 to 2012). Data were obtained using remote cameras placed along recreational trails adjacent to salmon spawning creeks: MC1, Meadow Creek, n = 224; SFER1 South Fork Eagle River, n = 184; SFCC1, South Fork of Campbell Creek, n = 2,105.

The most common trail users at all 3 sites were adult males, followed by adult females (Table 1). The most notable difference in the gender and age of users among the 3 trails was the relatively high proportion of children and teens observed at MC1 (10% per year or 22% of total groups). Many of these young people were not accompanied by adults. In comparison, all children and most teens observed at SFCC1 and SFER1 were accompanied by adults. Dogs accompanied groups of people most frequently at SFER1 (48% annually) compared to 34% and 21% of total groups annually at MC1 and SFCC1, respectively. Off-leash dogs outside of the detection area did not trigger cameras; therefore, it is likely that groups with dogs were undercounted. Average group size was <2 people at all sites (Table 1).

Among the 3 trails, users carried different personal items often associated with bear defense or safety, including bear spray and firearms. Relatively few groups using MC1 and SFCC1 (4 of 125 and 88 of 1264, respectively) carried bear spray, while 15 out of 124 of the groups using SFER1 carried bear spray. Similarly, only 6% (n = 8) and 1% (n = 10) of the groups at MC1 and SFCC1, respectively, carried a firearm. In comparison, 40% (n = 34) of the groups using SFER1 had at ≥1 person with a firearm. The proportions of groups observed with a handgun or bear spray were undoubtedly conservative, because these items may have been in packs or hidden by clothing or torsos. At least 1 person in 7 groups observed at all sites combined was carrying a cell phone. Four people were observed wearing ear buds at SFCC1 compared to no one at SFER1 and 2 people at MC1.

Discussion

Amount of human and bear activity

Despite their proximity to suburban neighborhoods, all 3 trails displayed brown bear sign, including tracks, scat, and partially eaten salmon. The most remote location (SFER1) had the least human activity and the most bear activity, followed by MC1 and SFCC1, which had the most human activity and least bear activity. Human activity influenced the bear activity observed at each site, and these variables were inversely related;

however, it is possible that bears were nearby, but out of the camera's detection zone. We found this to be true at the SFCC study site. An auxiliary camera located approximately 25 m from SFCC1, but along the creek, captured more bears than at the trail location. This bear activity could easily pose additional risk to the trail users. Based solely on the ratio of bears to people, the highest likelihood of encountering a bear occurred at SFER1.

Timing of bear and human activity

Most bear activity at all sites coincided with the peak of salmon spawning. Bears were observed just prior to the arrival of salmon in the creeks, and bear sightings tapered off as spawning ended during mid-September. In comparison, human activity was relatively consistent throughout the study period at MC1 and SFER1; however, human activity increased slightly in mid- to late September through October at SFCC1. Biking (the most common activity from July through September at SFCC1) may have been influenced by weather conditions, which were abnormally cool and rainy during the summer of 2010 (Halpin 2010). Further, since the mauling incidents at Rover's Run in 2008, the public has been advised repeatedly about the threat of bear encounters at that location during salmon spawning. The MOA and the Bureau of Land Management erected seasonal bear warning signs at either ends of the trail to notify users of the hazard. Such warnings also may have reduced human use during this time. In comparison, the remaining 2 sites (SFER1 and MC1) recorded very little human activity, and there was no apparent pattern in activity over the duration of the summer. Based on our data, human–bear encounters are most likely to occur from July through early September when human and bear activity overlap near salmon spawning streams.

Brown bears tend to avoid people when possible (Reinhart and Mattson 1990, Olson et al. 1998, Smith 2002), and we found that the timing of daily bear activity on trails was inversely related to human activity (Figure 9). Bears were observed more in the early morning, late evening, and during periods of darkness, while humans were more active during daylight. Olson et al. (1998) also found that brown bears

Figure 9. Bears on hiking trail.

adapted a crepuscular activity pattern with a midday depression in activity when people were present. Furthermore, brown bears have been found to avoid people spatially and temporally when foraging for spawning fish (Reinhart and Mattson 1990, Smith 2002) and can be highly successful foraging for spawning salmon in the dark (Klinka and Reimchen 2002). Because the bears at all 3 study sites exhibited a crepuscular and nocturnal activity pattern, it is probable that they were fishing on adjacent streams during hours of darkness or when people were less likely to be present.

The concern for public safety is highest during periods when people and bears overlap temporally and spatially. While most brown bears appear to have adopted a crepuscular and nocturnal activity pattern at our study sites, some people also used trails at night. Jope (1985) found that most grizzly bear charges and bear-inflicted injuries occurred in summer during crepuscular periods and on cool days.

In addition, bear behavior toward people may vary during darkness compared to daylight. For example, Reimchen (1998) found that black bears (*Ursus americanus*) moved away from people using trails during daylight, but during darkness were reluctant to move off a trail to avoid people. If this behavior pertains to brown bears, it could lead to surprise encounters that result in attacks. Indeed, one of the 3 maulings on Rover's Run and the only mauling documented on Meadow Creek happened shortly after midnight.

Bear activity was distributed relatively equally across days of the week, whereas human activity tended to be higher on the weekends and on Friday. We would, therefore, expect to see more adverse encounters on weekends due to the sheer number of people using trails. However, an individual's risk of encountering a bear would be equal across days of the week because bears showed no weekday pattern.

Human activity and bear awareness

Human activities and behavior influence the likelihood of a sudden encounter with a bear. Fast-moving recreational activities, such as biking and running, tend to be riskier than slower-moving activities, such as walking (Herrero 2002). Biking was a popular activity on Rover's Run (SFCC1), and 2 bikers and a runner have been mauled on this trail when they surprised brown bears at close range. Additional bikers and runners have reported close encounters with brown bears in municipal parks and Chugach State Park (J. Coltrane, Alaska Department of Fish and Game, unpublished data). Biking is rapidly growing in popularity in the Anchorage area, and there is a high demand for new single-track bike trails in municipal and state parks (H. Spoth-Torres, Anchorage Parks and Recreation, personal communication; Alaska Department of Natural Resources 2009). To mitigate brown bear encounters in Banff National Park, seasonal closures for biking have been instated on trails that bisect important berry habitat (Herrero and Herrero 2000). Similar seasonal biking closures on the trails adjacent to anadromous streams in the MOA may reduce human–bear conflicts.

Awareness of bears and understanding bear safety practices among the public can help mitigate negative bear encounters. Many people who used trails, however, did not appear to be prepared for encountering a bear at our study sites. Bear-safety experts recommend traveling in groups of 4 or more, because most serious or fatal bear attacks have happened to groups of 1 or 2 people (Herrero 2002); however, the average group size at all 3 study sites was <2. Experts typically recommend carrying a bear deterrent, such as bear spray. A minimum of 10% of groups documented at the study sites carried some kind of lethal or nonlethal bear deterrent, whereas 1% were actively using a cell phone or wearing ear buds, which can be a distraction. At MC1, the proportion of individuals actively using cell phones and the scarcity of bear spray and firearms suggest that the users did not consider the risk of a bear encounter to be high. Further, unattended children were often observed at this location. The proximity of the trail to a neighborhood and a high-volume highway most likely influenced the type of user, as well as the lack of preparedness observed. In comparison, most of the people using Rover's Run (SFCC1) were biking or running, and, therefore, were not carrying cell phones in hand; however, despite the highly publicized bear hazard on this trail, few were seen carrying bear spray or firearms. SFER1 was in a wild area with many signs warning people of the presence of bears. Consequently, many users appeared to be prepared for a bear encounter. Few people using SFER1 carried a cell phone in hand, and they had the highest incidence of bear spray and firearms on their person; however, even these proportions were lower than anticipated, as the majority of groups using SFER1 did not appear to be carrying any bear deterrent.

These use patterns and behaviors have implications for public safety and bear conservation. This study indicates that most trail users were either unaware of the recommendations or chose to ignore them. Although the Alaska Department of Fish and Game and the Anchorage Bear Education Committee, a multi-agency group, conduct numerous seminars on bear awareness and safety each year and publish bear safety materials for distribution to the general public (E. Manning, Alaska Department of Fish and Game, personal communication), Similarly, bear safety recommendations were not very effective at influencing visitor behavior in other areas, including Yellowstone National Park (Gunther 1990) and other backcountry areas in Montana (Braithwaite and McCool 1989).

Impact of human presence on bears

Individual bears respond differently to human activity. While some bears may adapt to the presence of humans by avoiding people temporally and spatially, others may avoid or abandon areas that have high levels of human use (Woodroffe 2000). Grizzly bears in Yellowstone National Park were more than twice as likely to be in the areas when human use was restricted or where it was unrestricted, but where people were inactive (Coleman et al. 2013). Similarly, we found that the amount of bear activity at our camera locations was inversely related to the amount of human activity.

Management implications

The recent increase of large carnivore populations in and around human communities (Linnell et al. 2001) poses challenges for wildlife and land management agencies. Brown bears are slowly returning to their historic ranges in the contiguous United States (Gunther et al. 2004), and confrontations between bears and humans are on the rise as the number of people in bear habitat increases (Martinka 1982, Mace and Waller 1996). Most members of the public typically do not support killing or removing bears to mitigate potential conflict, but instead support seasonal trail or area closures (Braithwaite and McCool 1989, McFarlane et al. 2007, Responsive Management 2010). For example, most Canadians accept seasonal or temporary closures of recreational trails or even permanent closures to conserve grizzly bears (McFarlane et al. 2007). Back-country users also accepted restricted access to protect bears and reduce human–bear conflicts (Braithwaite and McCool 1989). Similarly, most Anchorage residents appreciate bears in and near the city and are tolerant of them in large city parks and even neighborhoods (Responsive Management 2010). Due to the high safety risk, Anchorage residents also support the idea that important bear habitat should be avoided when relocating or building new trails (Responsive Management 2010).

While observational in nature, our study provides insight into human and bear activity that can be used to mitigate negative human–bear encounters on recreational trails without lethally removing bears from an area. Based on our data, a potential solution for avoiding dangerous bear encounters at our study sites and similar areas is to restrict human access either seasonally or completely. When human access is controlled in important bear habitat, distribution of visitors becomes spatially and temporally more predictable, allowing bears an opportunity to adjust activity patterns to avoid people while still using the resource (Aumiller and Matt 1994, Fagen and Fagen 1994, Wilker and Barnes 1998, Gibeau et al. 2002). Since the late 1970s, managers have proposed changing use patterns of visitors by rerouting trails, relocating designated campsites, and restricting human activity to periods when grizzlies were least likely to be present (Martinka 1982). To determine the most effective times and locations for seasonal or complete trail closures, managers can use remote cameras to better understand how bears and people use an area. Camera data can provide agency managers with a tool that will aid in delineating important sites for bears and protect them from unnecessary disturbance while reducing the likelihood of bear attacks. Our data also suggest that many people do not heed, or fail to remember, bear-safety advice from experts.

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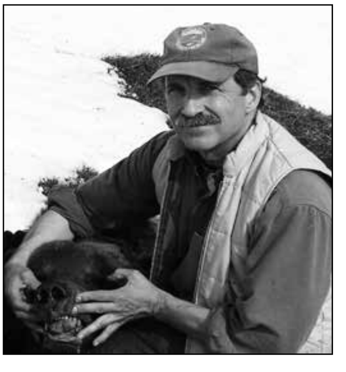

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