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Does diversionary feeding create nuisance bears and jeopardize public safety?

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Abstract: Diversionary feeding of black bears (*Ursus americanus*) around campgrounds and residential areas has received little study because of concerns that it might create nuisance bears and jeopardize public safety. To evaluate those concerns and assess its effectiveness in mitigating human–bear conflict, we studied diversionary feeding, habituation, and food-conditioning at a U.S. Forest Service campground and residential complex near Ely, Minnesota. During 1981 to 1983, 6 bears (2/year) had been removed from this area as nuisances; but during 8 years of diversionary feeding (1984 to 1991), the only removals were 2 bears that had newly immigrated to the periphery of the study area and had not yet found the diversionary feeding site. The reduction in nuisance activity was significant, despite continued availability of garbage and the fact that the study bears were habituated and food-conditioned. No bear that visited the diversionary-feeding site became a nuisance or jeopardized public safety, even in 1985, the year with the lowest bear food index and the highest number of nuisance complaints ever recorded throughout Minnesota. Diversionary feeding led to greater tolerance of bears by residents. My data indicate that hunger, not habituation and food-conditioning, creates bear–human conflicts.

***Key words*:** black bear, bear attacks, campgrounds, diversionary feeding, food-conditioning, habituation, human–wildlife conflicts, natural bear food, nuisance complaints, problem bears, supplemental feeding, *Ursus americanus*

As human residences spread into bear habitat, the potential for human–bear conflict increases (Conover 2002). Black bears (*Ursus americanus*) have a high tolerance for anthropogenic activities and readily adapt to artificial food sources (Spencer et al. 2007). Garbage, sunflower seeds (in bird feeders), and other human foods can lure bears into campgrounds and residential areas (McCullough 1982, Garshelis 1989, Beckmann and Berger 2003), but there has been little study of how food can lure bears away from problem situations (Rogers 1989, Stringham 1989, Craighead et al. 1995). One reason for this lack of study is a concern that habituated, food-conditioned bears might become nuisances or jeopardize public safety. However, in Slovenia, bear damage in diversionary-feeding areas was only a third that in other areas, despite bear populations up to 6 times greater in the feeding areas (Klenzendorf 1997). Diversionary feeding has proven effective in reducing damage to trees by black bears in the Pacific Northwest (Ziegltrum 2004, 2008) and in reducing crop damage by ducks, white-tailed deer (*Odocoileus virginianus*), and rats (*Rattus* spp.; Conover 2002).

To evaluate diversionary feeding as a means to mitigate human–bear conflict and to evaluate concerns about habituation and food-conditioning, I conducted diversionary feeding tests at a U.S. Forest Service (USFS) campground and residential complex near Ely, Minnesota, during 1984 to 1991. The term habituation, as used in this paper, is the waning of a bear's fear of humans; food-conditioning refers to a bear's learning that certain locations, situations, or humans may provide food. I intentionally used food-conditioning to facilitate habituation at the diversionary feeding site.

Study areas

The diversionary study area was a 6.6-km stretch of residences and campsites along the Kawishiwi River in the Superior National Forest, 18 km southeast of Ely, Minnesota. All sites had nonbearproof dumpsters and garbage cans, andit had a history of bear problems to the extent that 6 bears (2/year) had been removed as nuisances or for approaching people during 1981 to 1983. Garbage cans and dumpsters were nonbearproof (Figure 1). We placed the diversionary feeding site near the middle of this area at USFS Kawishiwi Field Laboratory (47° 49'N, 91° 44'W).

The problem areas were the following distances from the feeding site.

- A roadside rest area beside Minnesota State Highway 1 was 0.25 km to the northeast.
- A USFS swimming beach and picnic area was 0.5 km to the northeast.

- A 31-site USFS campground was 0.5 to 1.0 km to the northeast.
- Sixteen homes were 0.3 to 2 km to the northeast.
- Voyageur Outward Bound School with >30 cabins was 2.7 to 3.2 km to the northeast. The cabin doors had no latches and often had open windows.
- Twenty-six summer homes were 1.2 to 3.4 km to the southwest.

For comparison, I monitored radio-collared and ear-tagged bears in an adjacent study area centered at 47° 44′N, 91° 38′W, described by Rogers (1987). In that study area, bears had been studied since 1969, dumps were closed in 1975, and no diversionary food was given.

The entire region was within the Canadian Shield ecological complex and had mixed coniferous-deciduous forest with little oak (*Quercus* spp.) and no beech (*Fagus grandifolia*) or hickory (*Carya* spp.). Soils were shallow and noncalcareous with low fertility (Rogers 1987). Preferred bear foods that influence nuisance behavior through wide variations in abundance from year to year included hazelnuts (*Corylus cornuta*), berries, and ant broods (Rogers 1976).

Figure 1. With diversionary feeding, removals of problem bears were reduced 88%.

Methods and materials

The diversionary feeding site was a box of food placed on a pad of tracking sand 8 m from a building with flood lights, a window, and living quarters for observers. Beef fat was the primary diversionary food with the exception of 50 kg of grapes added during July 6 to 21, 1984. I replenished beef fat in unlimited amounts during 1984 to 1985 and in limited amounts during 1986 to 1991. During July 15 to September 30, 1984, I weighed the box of food before and after each bear fed from it. On nights when observers were not present, I weighed the box in the evening and morning and pro-rated amounts eaten among the 3 bears, which could be identified by their tracks.

I captured bears near the feeding site for ear-tagging, radio-collaring, and age determination. For bears whose years of birth were unknown, I determined ages from cementum annuli in a first upper premolar or from a combination of head shape, baculum length, testicle size, nipple characteristics, weight, body length, width of forepaw, and distance from gum to cementum-enamel interface on an upper canine tooth (McMillin et al. 1976, Brooks et al. 1998, McRoberts et al. 1998). I identified bears by ear-tag number and placement, radio-collar frequency, sex, coat color, muzzle color, chest blaze, eyebrow patches, scars, and tracks.

To facilitate comparisons of nuisance activities before diversionary feeding began (1981 to 1983) and during the study (1984 to 1991), I did not reduce attractants in the study area. Dumpsters and garbage cans remained nonbearproof. Advice to campers did not change, and residents continued to feed birds and manage their garbage as usual. In addition, I intentionally habituated and food-conditioned bears to my presence by hand-feeding and stroking bears that would tolerate it.

I monitored bears using telemetry, ear-tag returns, and direct observation. In the diversionary study area, observers included residents, USFS campground employees, hunters, and volunteers. Researchers and assistants routinely accompanied habituated bears up to 48 hours at a time between September 1985 and September 1991 (Rogers 1987, Rogers and Wilker 1990; Figure 2).

To the extent possible, I monitored study bears until their deaths to determine the extent to which their behaviors and fates were altered

Figure 2. The author routinely accompanied bears to record data on habitat use and diet.

by diversionary feeding, habituation, and food-conditioning. For comparisons, I used Minnesota Department of Natural Resources (DNR) statewide bear nuisance summaries and kill records (Garshelis and Noyce 2007), reports from district wildlife managers, newspaper accounts, and data from the long-term ecological study I conducted simultaneously (Rogers 1987).

Results

Overall

No bear that visited the diversionary feeding site became a nuisance or jeopardized public safety. In the 3 years prior to the study (1981 to 1983), 6 bears (2/year) were removed from the study area as nuisances or because they approached people; but in the 8 years of diversionary feeding (1984 to 1991), the only removals were 2 bears that had newly immigrated to the periphery of the study area and had not yet found the diversionary feeding site. This removals was 88%. The reduction in nuisance activity with diversionary feeding was significant (t = 4.14, df = 9, $P \leq 0.002$).

1984

Natural food abundance in the region. Bear food in northeastern Minnesota was moderately abundant in 1984 (Garshelis 2002). It included greens and ant pupae in late spring and early summer, and hazelnuts, blueberries (*Vaccinium* spp.) and wild sarsaparilla (*Aralia nudicaulis*) berries in mid- to late summer.

Visits to the feeding site. Eight bears visited the feeding site from the time observations began on June 1 and the last bear visit of the year on September 30, 1984. Male 430, a 5-year-old resident bear, passed through the feeding area on June 21 (mating season) without eating and did not return in 1984. Male 405, a 2-year-old immigrant, visited the feeding site 10 times between and July 12 and July 29. Female 403 was a 6-year-old resident whose territory included the 26 summer homes southwest of the feeding site. She brought her 2 yearlings (females 401 and 429) to the feeding site 8 times between June 1 and the day of family breakup on June 13. After the separations, female 403 visited alone 10 times through August 13, female 401 visited on June 18, and female 429 did not return in 1984. Female 812 was a 10-year-old resident whose territory included the USFS facilities and the 16 homes northeast of the feeding site. She had been an occasional visitor with her cubs in the campground in 1983. In 1984, she brought her 2 male yearlings (1 black, 1 brown) to the feeding site on June 10, the day of family breakup. After that, she visited alone 26 times through July 31, the black yearling visited 4 times through July 18, and the brown yearling visited 74 times through September 30.

Effectiveness of diversionary feeding. For the first time in 3 years, campground officials did not consider any bear a nuisance, including female 812 and her yearlings that had been nuisances in the campground the year before. This lack of nuisance complaints throughout the study area was despite a moderate number of nuisance complaints (927) statewide (Garshelis 2002). Although bears do not highly prefer beef fat, it diverted the bears from human foods until preferred berries and hazelnuts ripened in mid-summer. USFS campground manager Joseph Lekatz wrote in his 1984 year-end report that diversionary feeding is "working well in the Kawishiwi Campground vicinity" and that no bears approached him for food. Although female 812 and her 2 cubs visited the campground several times in 1983, no bear was reported there in 1984. On 3 dates, one or the

other of bear 812's independent yearlings passed by the campground toward the feeding site without attempting to obtain food or approach people at the campground. Immigrant bear 405 was first seen at an open dumpster, but 2 days later, on July 12, he visited the feeding site 1 km away and was not reported in a problem area again.

Bears that were habituated and food-conditioned at the feeding site avoided people elsewhere, and none was killed by hunters in the September-October hunting season. The radio-collared female (403) held a territory similar in size to those of bears without diversionary food in the adjacent study area (Rogers 1987). Behavior at the feeding site varied from timid and nervous to trusting but was not threatening.

1985

Natural food abundance in the region. This year contrasted with 1984 in having the lowest statewide bear food index recorded by the Minnesota Department of Natural Resources (DNR) in 23 years of surveys (Garshelis and Noyce 2007). In May and June, rainfall in the study area was 48% higher than the 32-year average (Doran 2009), hampering ant reproduction and flooding swamplands where bears would normally feed on wild calla (*Calla palustris*) and blue joint grass (*Calamagrostis canadensis*). Record low temperatures of -6° C (Soudan, Minn.) and -8° C (Embarrass, Minn.) on June 3 killed berry and hazelnut (*Corylus cornuta*) blossoms, reducing mast production in July and August. The food shortage extended throughout northeastern Minnesota (Garshelis and Noyce 2007).

Nuisance activity in the region. Nuisance complaints statewide in 1985 were the highest recorded by the DNR (2,859) in 22 years of such record keeping (Garshelis and Noyce 2007). Bears in Canada and northeastern Minnesota migrated south in a pattern similar to migrations of past years of food shortage, migrating south to Lake Superior and into cities along the shoreline (Schorger 1946, 1949; Rogers 1987). Landowners and officials shot hundreds of nuisance bears around residences, including 70 animals in Thunder Bay and 90 animals in Duluth (Rogers 1987).

Three bears that were killed in Duluth and tagged during our long-term study area were 90 and 107 km outside their usual home ranges. Female 664's trip to Duluth (107 km) was the first known trip by the 24-year-old made outside her territory in 11 years of radio-tracking. Of 11 bears killed from that study, seven were 20 to 107 km outside their usual ranges. Study bears were killed in larger numbers and farther from their usual ranges than in any other year of that study (Rogers 1987). They included a disproportionate number >14 years of age (Rogers 1987).

Some bears traveled south around the tip of Lake Superior into the oak forests of Wisconsin and east central Minnesota (Rogers 1987), as has been observed in the past (Schorger 1946, 1949). Bears were forced to turn to less preferred foods, including human foods, and an unusual number was attracted to garbage dumps where fights over food resulted in bears sustaining a broken leg, a 12-cm laceration, and a nose pad bitten off (Rogers 1987). An unusual number of bears was also attracted to hunters' baits during the September-October bear-hunting season. Hunter success rose from 20% in 1984 to 52% in 1985 (Joselyn and Lake 1987). The number of bears killed by hunters in northeastern Minnesota rose from 180 during 1984 to 424 in 1985 (Joselyn and Lake 1985), in addition to the hundreds killed before hunting season began.

Natural mortality in the region. Food shortage and increased travel caused the greatest annual weight loss rate among adults and the highest starvation among cubs and yearlings in the long-term study since the study began in 1969. Of 10 cubs observed with mothers that did not visit the feeding site, only 4 cubs survived through August. Four females 11 to 20 years old averaged 68 kg (61 to 75 kg) in March 1985 and 51 kg (49 to 54 kg) in March 1986. Of 7 yearlings that accompanied three of those females in 1985, only 1 yearling survived. Two yearlings that accompanied the fourth female died, and it took the mother until 1988 to produce another litter. Two of the other females also delayed producing cubs for 1 to 2 years beyond what would be expected. The oldest female of the four (20-year-old female 641) fared the best. One of her 2 yearlings was the one that survived, and she produced a litter of 3 cubs in 1986, one of which survived.

Visits to the feeding site. Natural food shortage and rampant nuisance activity across

the region provided an unusual opportunity to study diversionary feeding. Beef fat was made available at the feeding site from early April until late October, which included the period of bear activity. Seven of the 8 bears that had visited the feeding site in 1984 returned in 1985. Five new young males and no new females (excluding cubs) visited in 1985. The new males were first seen on May 27 (Morris), May 30 (4-year-old 428), June 12 (Schnoz), June 12 (Jimmy), and June 23 (Donald).

Each day a bear visited the feeding site was considered a visitor-day no, matter how brief the visit or how many times it visited on that day. A visit by a mother with cubs was considered 1 visitor-day. I recorded 7 visitor-days by 1 bear in April, 52 by 6 bears in May, 138 by 12 bears in June, and 64 by 9 bears during July. During 202 visitor-days from June 1 to July 25, 12 bears (plus their 5 cubs) ate 228 kg of beef fat.

Nuisance activity in the study area. Although nuisance activity was rampant throughout Minnesota in 1985, residents and campground workers reported no problem in the study area. Isolated incidents that did not rise to the level of nuisance behavior included an unknown bear feeding once from an open dumpster on June 29 and Schnoz passing through the campground without causing a problem on July 13. Despite the high mortality across the region in 1985, no bear was killed in the diversionary feeding study area.

1986 to 1991

During these 6 years of follow-up studies, I monitored nuisance activities, diets, travels, and fates of the resident bears, while providing only limited food at the feeding site.

Natural food abundance. DNR surveys found bear foods to be generally normal in northeastern Minnesota throughout this period (Garshelis and Noyce 2007). However, local rainfall in August 1991 was only 20% of normal (2.3 cm vs.11.2 cm; Doran 1009), creating a severe berry shortage in late summer.

Nuisance activities in the study area. With 3 exceptions, diversionary food kept bears from becoming problems. One exception was a captive-raised cub (Gerri) that was released into the study area in 1989. She ate mainly natural foods but visited residences and the campground repeatedly in 1990 and 1991

Figure 3. Two immigrants that had not yet found the diversionary feeding site were translocated.

and was returned to captivity in 1992. Her antics are excluded from all statements in this paper. The other 2 exceptions were adolescent males that had newly immigrated to the periphery of the study area in 1991 and had not yet found the diversionary feeding site. In early July, one of them scattered garbage at Voyageur Outward Bound School, 2.8 km from the feeding site. On September 9, the other attempted to break into an occupied house 3.2 km southwest of the feeding site during the period of very scarce natural food. Both were immediately translocated (Figure 3).

Intensive habituation and food-conditioning

By the end of 1985, I learned the benign meanings of ferocious-looking displays and began to realize that behaviors I earlier interpreted as threats or aggression were harmless expressions of nervousness. By that time, radio-collared Female 401 became trusting enough that researchers could walk with her as described by Rogers and Wilker (1990). Four other bears and their cubs provided similar opportunities over the next 6 years, allowing us to walk with them for 24 to 48 hours at a time. Researchers spent thousands of hours alone with the bears, including mothers with cubs. The bears roamed wild with uncontrolled access to the public. No one was harmed. Observations

of these bears revealed how habituated, food-conditioned bears with access to supplemental food spend their time in the forest.

The bears maintained territories, daily activity cycles, travel patterns, and diets similar to those described for bears in the long-term study without diversionary food (Rogers 1987, Rogers and Wilker 1989). In that study, 40% of the females and 67% of the males made forays >7 km outside their usual areas. Bears in the diversionary feeding study made similar forays. For example, on July 30, 1991, 6-year-old Terri and her 2 cubs began traveling 66 km to an unusually productive hazelnut stand where they foraged for the remainder of August before returning to their territory. At the same time, three of 6 radio-collared bears from the long-term study moved similar distances to the same area of hazelnut abundance. In another example, 7-year-old male 430 was killed by a hunter 173 km outside his usual area on September 6, 1986.

Reproduction

Three females that received supplemental food from the time they were cubs produced their first litters at 3, 3, and 4 years of age. Their average age of first reproduction (3.3 years) was significantly younger than the average (6.3 years) for 17 non-fed females in the long-term study area ($\chi^2 = 6.21$, df = 1, $P = 0.01$).

Fates of study bears

None of the resident bears (excluding captive-raised Gerri) became nuisances. None of them jeopardized public safety. Of the 8 resident bears, 5 were killed by hunters, 4-year-old female 401was killed by 13-year-old female 812 in a territorial dispute, and the fates of 2 bears aged 2 (female 429) and 9 (female 403) are unknown. None was removed as a nuisance.

Despite being habituated and food-conditioned, bears killed by hunters had an average age 2 to 3 times the age of those in the general population. The average age of bears killed by hunters in Minnesota is 2 years for males and 3 years for females (Garshelis and Noyce 2007). By contrast, male 430 was shot by a hunter at the age of 7 years, and the average age of the 4 resident females killed by hunters was 7 years.

Discussion

Bears that visited the diversionary feeding site continued to forage for natural foods and did not become nuisances. This was in contrast with the frequent bear problems in the study area before the study began and the bear problems in other areas during the study, especially in 1985 when natural food reached record lows. Our data indicate that hunger—not habituation or food-conditioning—is the driving force behind nuisance behavior.

Probably the most revealing aspects of this study are what the bears did not do. Study bears did not become "hooked" on easy handouts and did not become lazy and dependent. They continued to demonstrate a strong preference for natural foods as has been found for other fed bears in Minnesota (Rogers 1989), Virginia (Gray et al. 2004), and Washington (Ziegltrum 2008). They sought a variety of natural foods where possible and settled for less preferred foods, including beef fat at the feeding site, where necessary. Being habituated and food-conditioned did not cause them to change their food preferences. They did not become increasingly aggressive in trying to obtain food from people.

Part of the belief that food-conditioned bears become increasingly aggressive in trying to obtain human foods may stem from misinterpretations of bear behavior. Harmless nervous bluster is often misinterpreted as an indication a bear is aggressive and a threat to public safety, rather than a frightened, nervous bear performing ritualized displays with no intention of attacking. Trustful bears seen in daytime are often misinterpreted as bold rather than as bears exhibiting normal circadian activity patterns.

None of the consequences of habituation and food-conditioning predicted by Geist (2011) materialized. I saw no "unconsummated interest" in people (Geist 2011). Instead, the bears generally ignored researchers and allowed them to accompany mothers with cubs, day and night, for up to 48 hours at a time. Habituation to humans is the normal response of bears that see many people and are not aversively conditioned.

The belief that habituated bears pose

increased threat to public safety runs contrary to a growing body of data from Tennessee (Tate 1983), Michigan (DeBruyn 1999), Minnesota (Rogers 1989, Rogers and Wilker 1990, Becklund 1999), Alaska (Herrero et al. 2005), and elsewhere (Stringham 1989). Habituated bears are less likely to attack on a per-encounter basis (Herrero et al. 2005). Of 63 fatal attacks by black bears in North America during 1900 to 2009, 49 deaths (78%) were in Canada or Alaska, and only 14 deaths (22%) were in the lower 48 states (Herrero et al. 2011). There were 3.5 times as many fatal attacks in Canada and Alaska despite there being only 1.75 times as many black bears and much less human contact in Canada and Alaska (Herrero et al. 2011).

Herrero et al. (2011) stated that most bears involved in fatal attacks were not known to have had a history of association with people. However, they also state that in 38% of fatal black bear attacks, people's food or garbage were present. It is well-known that food can lead bears into conflict situations (Beckmann and Berger 2003). I used diversionary feeding to successfully lead bears out of conflict situations.

The fed bears showed no evidence of illness, such as might be spread at the feeding site. A broad search of the literature revealed no evidence of any communicable disease epidemics among black bears and no evidence of disease being spread at garbage dumps (Rogers and Rogers 1976, Rogers 1983).

Young males that visited our feeding station dispersed from their mothers' territories at the same ages as non-fed bears in the long-term study (Rogers 1987). Female 403 shifted her home range away from the feeding site when her territory became crowded with 3 maturing daughters, as was also reported in the long-term study for mothers with growing daughters (Rogers 1987). The feeding site did not attract females whose home ranges were not adjacent to it. Fersterer et al. (2001) reported that home range sizes of bears that ate diversionary food in Washington did not differ from home ranges of bears in other areas.

Both habituation and food-conditioning were specific to location and situation. Bears that were calm and trusting when people behaved in predictable, nonthreatening ways fled when people behaved aggressively or approached too quickly. Each new situation and location required additional habituation.

A problem that bears and bear managers faced in the study area before diversionary feeding was that residents would not coexist with animals they feared. The feeding site enabled residents to meet the bears and set aside the ferocious images of the media, the unnatural snarls of taxidermy, and the ubiquitous warnings they had heard. They saw the timid wariness that typifies black bears, the harmless bluster of nervous bears, and the calm trust some bears developed. They learned firsthand that mothers with cubs are not likely to attack. Residents who visited the feeding site shared their experiences with their neighbors, and the mere sighting of a bear was no longer a reason to call the DNR with a complaint.

Management considerations

Fearful public attitudes and widespread misconceptions are a major detriment to bear management. Diversionary feeding provided an opportunity for residents to meet the bears they feared and to develop more tolerant attitudes. In the study area, diversionary feeding reduced nuisance problems, despite the fact that the bears were habituated and food-conditioned. The fact that there was also continued availability of garbage in potential problem areas indicates that any efforts to mitigate problems by reducing attractants or aversive conditioning are likely to be more successful if coupled with diversionary feeding. There is a need for decision-makers to reevaluate policies toward habituated bears, recognizing that habituation is a normal response to people in the bears' increasingly urbanized environment and that habituated bears have not shown themselves to be a greater threat to public safety than non-habituated bears. There is a need for further study to determine the situations in which diversionary feeding can be most effective in mitigating human–bear conflict.

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