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Is diversionary feeding an effective tool for reducing human–bear conflicts? Case studies from North America and Europe

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Abstract: Diversionary feeding uses food to lure animals away from areas where they are unwanted or could cause conflicts with people. With bears (Ursidae) increasingly attracted to human food sources worldwide, diversionary feeding represents a seemingly logical and publicly acceptable means of alleviating conflicts. Feeding wildlife is widely practiced in Europe to enhance hunting and reduce conflicts, but feeding of bears is discouraged across North America. The efficacy and potential side-effects of bear feeding remain an open question because of a lack of rigorous studies. Here we examine 5 case studies from which we attempt to draw inferences about feeding as a conflict-mitigation strategy. Studies included U.S. national parks, where after bear feeding was banned conflicts were reduced; Aspen, Colorado, where lucrative dumpsters in town did not divert bears from using human-related foods at other sources; rural Minnesota, where results of intentional feeding of a small sample of bears were confounded with other variables; the Tahoe Basin of California–Nevada, where an emergency feeding effort during a drought-caused food failure seemed to reduce conflicts within approximately 1 km of the feeding site; and Slovenia, where a high density of feeders at established locations seemed to divert bears from using settlements during autumn hyperphagia. Although none of these studies were true experiments with treatments and controls, the range of circumstances yielded insights into when feeding could be effective: when food demands are not readily met by natural foods; when the provisioned food is easily found outside the potential conflict area; when the food is attractive; and when bears do not associate the feeding with people. However, long-term feeding may increase bear population size, which may increase conflicts overall, or trigger a demand for population control. Diversionary feeding, if used, should be conducted as an adaptive management strategy by professionals so as to learn more about factors influencing its effectiveness.

Key words: adaptive management, conflict mitigation, effects of feeding, fed bear is a dead bear, feeding ban, habituation, intercept feeding, supplemental feeding, \textit{Ursus americanus}, \textit{Ursus arctos}

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Human-dominated landscapes offer novel and predictable food sources to wildlife that are often more calorically rich and easier to obtain than wild foods (Shochat 2004, Baker et al. 2008, Ditmer et al. 2016). Of the 8 species of bears (Ursidae), all but the giant panda (\textit{Ailuropoda melanoleuca}) are attracted to human foods and thereby spend time in proximity to humans, thus increasing the potential to cause damage to property and threaten human safety (Herrero et al. 2005). Historical records indicate that bears have been feeding on human crops and livestock (Cardoza 1976) and breaking into houses (Steller 2003) since at least the 1600s in North America and Asia, and likely well before that in Europe (Zedrosser et al. 2011).

Methods for reducing human–bear conflict have taken many forms. Killing bears is the oldest and most direct means of mitigating bear damage. It can be effective, depending on the situation and how it is conducted (Raithel et al. 2016), but may be illegal or at least unpopular with local constituencies (Manfredo 2008, Messmer 2009), and may hamper growth of small bear populations.
(Morehouse et al. 2016). Physical barriers, repellents, behavioral conditioning, and relocation are other non-lethal methods used to reduce bear damage (Can et al. 2014). The success of these methods varies with the particular circumstances. As human–bear conflicts increase across the globe due to shrinking bear habitat, expansion of people into bear habitat, or expansion of bear ranges, there is growing demand for more varied, effective, and publicly acceptable tools for conflict mitigation (Can et al. 2014).

One such potential tool is “diversionary feeding.” The principle of diversionary feeding is that a food source is provided to try to divert the animals away from using another food source where their feeding could cause damage.

Bears are generally more attracted to human foods, and hence cause more conflicts, when their natural foods are scarce (Zack et al. 2003, Oka et al. 2004, Oka 2006, Garshelis and Noyce 2008, Baruch-Mordo et al. 2014, Johnson et al. 2015, Artelle et al. 2016). It therefore stands to reason that, especially when hungry, bears could be lured away from one potential attractant by the provision of alternative easily accessible food. Diversionary feeding has wide public appeal because it addresses the human–bear conflict problem without killing or relocating bears, and at the same time may satisfy bears’ hunger. Hence, in some recent outbreaks of excessive bear conflicts associated with food failures in the United States and Canada, public groups have pressured management agencies to attempt to solve the problem by feeding. Public pressure to use this technique is likely to become increasingly common, prompted by websites touting the virtues of diversionary feeding (Kvatun 2010). Wildlife feeding is already widely practiced in many countries in Europe and in some countries is well-accepted as a strategy to reduce conflicts with bears (Kavičič et al. 2013).

Application of diversionary feeding to mitigate conflicts with other medium to large mammal species has yielded equivocal results. For example, effectiveness of feeding to alleviate forest damage caused by browsing of wild ungulates varied depending on the temporal and spatial scales investigated (Gunderson et al. 2004; Putman and Staines 2004; van Beest et al. 2010 a, b) and by degree of preference for the tree species that the ungulate was browsing and damaging (Mathisen et al. 2014). In a review of the literature on ungulate feeding, Milner et al. (2014) found that the positive effects of diversionary feeding were often undercut by commensurate increases in ungulate density. Feeding has been shown to sometimes have unintended consequences on the target species (e.g., reducing home range size; Jerina 2012, Massé et al. 2014) or non-target species (e.g., ungulate feeding affecting birds; Mathisen and Skarpe 2011, Selva et al. 2014; vulture (Gyps spp.) feeding increasing local mammalian carnivores: Yarnell et al. 2015). In various controlled experiments aimed at reducing predation of grassland-nesting birds by meso-carnivores—including red foxes (Vulpes vulpes), raccoons (Procyon rotundus), and striped skunks (Mephitis mephitis)—diversionary feeding was effective (Vander Lee et al. 1999), effective for some species but not overall (Greenwood et al. 1998), or totally ineffective (Conover et al. 2005), depending on the specific conditions. In the long term, such feeding may actually increase these predator populations (Clark et al. 1996). In fact, local density of omnivorous predators was inadvertently increased by feeding of deer, consequently increasing predation on ground-nesting birds (Cooper and Ginnett 2000). Likewise, unexpected secondary effects of diversionary feeding have been observed in programs directed at smaller mammals and avian taxa, and such feeding programs have generally had mixed success or difficult-to-measure outcomes (Kubasiewicz et al. 2016).

One of the most notable successes of diversionary feeding has been in the reduction of bark-stripping and foraging on sapwood of coniferous plantation trees by American black bears (Ursus americanus; hereafter, black bears) in the Pacific Northwest, USA (Partridge et al. 2001; Zieglerm 2004, 2006, 2008). In less well-known examples, grizzly bear (U. arctos) predation on moose (Alces alces) calves and livestock has been effectively reduced through judicious baiting involving the redistribution of moose and livestock carcasses (Boertje et al. 1993, Madel 2009). However, a similar provincial program in Alberta, Canada, which created feeding sites from road-killed ungulates to intercept grizzly bears headed to livestock calving areas, proved to be ineffective: only a few dominant males used the bait sites and, when the program was suspended, none of these were involved in cattle conflicts anyway (Morehouse 2016). Likewise, whereas provision of diversionary baits of bakery wastes reduced caribou (Rangifer tarandus) calf predation by black bears, coyote (Canis latrans) predation increased commensurately, resulting in little improvement to calf survival (Lewis el al. 2017).

A number of ad hoc applications of diversionary feeding have also been attempted to alleviate conflicts with bears in communities, but most have not been well-documented, nor carried out in a way that yielded clear conclusions about its effectiveness. For example, in 1949, an acute food shortage in northeastern Minnesota prompted an influx of black bears into towns and farms.
Feeding stations were established along the outskirts of the city of Duluth (human population at that time approx. 100,000) in an attempt to keep bears from entering the city. Whether this feeding reduced the number of bears inside the city is unknown, but 25 bears were nonetheless shot within the city limits and 38 others shot in 2 neighboring towns (Petraborg et al. 1950).

Here, we examine the potential benefits or harm of the use of diversionary feeding specifically to alleviate bear conflicts near human development or human centers of activity. Feeding of bears has been highly discouraged by most government wildlife management agencies in North America because it conditions bears to anthropogenic attractants and may habituate them to people, and thus may prompt more conflicts in the long term (Geist 2011). One exception is the baiting of bears by hunters, which is allowed in some states and provinces to achieve desired harvests (Hristienko and McDonald 2007). However, in many countries in Europe, feeding of bears, either intentionally or as a byproduct of feeding other species, is commonplace and widely accepted as a method to improve hunting or viewing (i.e., enhancing success as well as producing large trophy animals) or to reduce conflicts (Apollonio et al. 2010, Kavčič et al. 2015); nevertheless, this practice has recently been questioned in terms of efficacy and unintended side-effects (Kavčič et al. 2015, Krofel and Jerina 2016). Given that human–bear conflicts are likely to continue to rise, we believe it is valuable and timely to make a careful and critical examination of this potential conflict mitigation tool.

We begin by defining terms related to feeding of bears. Next we provide an historical review from national parks in North America, where feeding was once prevalent but was proactively stopped, and where associated records were kept on human–bear conflicts. This case study is presented mainly to show relationships between conflicts (property damage and injuries) and certain kinds of feeding, which ultimately led to the “feeding is bad” paradigm in North America. We then review case studies measuring some of the effects of bear feeding near residential areas. Unfortunately, none of these case studies was a true empirical test of diversionary feeding, but they represent the best information currently available on the efficacy of this technique for changing bear behavior and reducing conflicts near human centers of activity. We cite previously published studies using diversionary feeding to reduce other types of conflicts (e.g., agricultural damage), but do not review them here as case studies. We critically interpret the findings from these case studies in order to provide an assessment of what we know about the use of feeding to alleviate human–bear conflicts.

Definitions

Feeding of bears may be conducted for a variety of reasons and circumstances. Here we define terms to describe types of feeding, which are often used interchangeably in the literature:

- **Diversionary feeding** (also called intercept feeding): provision of alternative foods or relocation of existing foods in an attempt to divert bears away from sites or food sources where they could cause conflicts with people.
- **Supplemental feeding**: intentional feeding for the purpose of enhancing nutrition, thereby improving bear survival, increasing reproduction, or increasing body condition and size.
- **Baiting**: setting food at a site to attract bears for hunting, viewing, photography, or for trapping bears for research, management, or harvest.
- **Recreational feeding**: deliberate feeding intended to lure bears closer for personal entertainment, viewing, or photography.
- **Commercial feeding**: feeding done for the purpose of attracting bears for others to watch or photograph as part of a business or other enterprise.
- **Research feeding**: providing food for bears to habituate them to human presence so they can be approached closely for scientific study.
- **Unintentional feeding**: leaving human-related products accessible for bears to feed upon; examples include garbage, bird seed, dog food, crops, and unprotected apiaries.

Some of these terms overlap. For example, a person who sets out food to attract bears for personal viewing is baiting and recreationally feeding; however, if the bear is hand-fed it would not be baiting and instead could be considered recreational or commercial feeding depending on the size of the operation. Likewise, baiting can be used to attract bears for hunting while also serving the dual purpose of providing more nutrition to create bigger trophy animals or enhance reproduction (Gray et al. 2004). Also, unintentional feeding may be diversionary. For example, a crop field may attract bears during a year with a shortage of natural food, and may serve to keep these individuals from seeking food closer to a community. We would not consider that situation diversionary feeding, though, unless there was a deliberate decision to allow bears to feed in the field with the intent of discouraging them from feeding elsewhere.

We note that supplementary and diversionary feeding are also somewhat intertwined. Supplementary feeding is used to improve animal nutrition, but in so doing could reduce consumption of other foods, thus alleviating
damage to human property or natural vegetation. Diversionary feeding is specifically directed at reducing conflict, but more in terms of shifting animals spatially away from another food source rather than satiating them (although it may do that as well). Some authors have opted for the term “diversionary baiting” (Stringham and Bryant 2015) instead of diversionary feeding because feeding of bears has the connotation of a person being present, whereas baiting suggests a remote process of attracting bears to a site. With this caveat in mind, we nevertheless retain the term diversionary feeding because it is well-rooted in the literature. Moreover, it conveys that bears are not just lured away by a small bait, but by an adequate provision of food to keep them from seeking other human-related foods over an extended period.

Bear feeding in U.S. national parks: the Yellowstone experience

The classic image of bear feeding is probably nowhere more firmly epitomized than in U.S. national parks during the early–mid 1900s. We present this case study to show how such feeding led to increasing conflicts and ultimately a complete reversal in philosophy about feeding bears, either intentionally or unintentionally, which persists to this day in North America. The premise of this philosophy is that once conditioned to anthropogenic foods, bears are more likely to damage personal property or injure people (Herrero 1985), that mother bears teach this bad behavior to their cubs (Mazur and Seher 2008, Hopkins 2013, Morehouse et al. 2016), and ultimately many of these bears must be captured and removed (i.e., euthanized or sent to a zoo). The catchphrase “a fed bear is a dead bear” was popularized as part of the U.S. National Park Service’s campaign to educate park visitors about the potential negative consequences of bears regularly obtaining anthropogenic foods. Although we could not identify the original source of this slogan, it quickly captured public attention because it connected what many park visitors thought of as a compassionate action (feeding bears) with an unintended negative consequence (modification of the bear’s behavior to the extent that it would have to be removed).

National parks managing bears under the “a fed bear is a dead bear” philosophy include (but are not limited to) Denali (Dalle-Molle and Van Horn 1989), Glacier (Gniadek and Kendall 1998), Grand Teton (Grand Teton National Park 1989), Great Smoky Mountains (B. Stiver, Great Smoky Mountains National Park, personal communication, 2011), Shenandoah (Garner and Vaughan 1989), Sequoia and Kings Canyon (Zardus and Parsons 1980), Yellowstone (Cole 1971), and Yosemite (Harms 1980) National Parks in the United States; and Banff, Jasper, Kootenay, Waterton, and Yoho National Parks in Canada (Herrero and Higgins 1999). Both brown–grizzly bears and black bears fall under the National Park Service policy against feeding.

Yellowstone National Park (YNP) has arguably the best record demonstrating the consequences of curtailed bear feeding. Yellowstone National Park has extant populations of both grizzly and black bears and is visited by approximately 3.5 million people annually, mainly (92%) during the May–October active bear season (Gunther 2012). Although park visitation fluctuates annually, visitation has been steadily increasing with new records set almost every decade.

During the early history of Yellowstone and several other U.S. national parks, bears obtained anthropogenic foods from 4 primary sources (Schullery 1992): (1) open-pit garbage dumps (unintentional feeding); (2) unsecured foods and garbage in developments, roadside campgrounds, and backcountry campsites (unintentional feeding); (3) recreational hand-feeding by park visitors along roads and in developments; and (4) feeding stations where visitors could sit in bleachers and watch bears feed on garbage (Table 1). These feeding stations, which evolved from the viewing of bears feeding at hotel garbage piles, were intended as safe places for public enjoyment (commercial feeding) as well as to keep bears out of the park’s campgrounds (diversionary feeding; Wondrak Biel 2006).

Historically (since approx. 1880), many visitors came to YNP specifically to see bears close up. Many bears in the park became food-conditioned and waited (‘begged’) along roads for human handouts. Although attacks on people were rare, injuries related to recreational hand-feeding of bears were increasingly common (Gunther and Hoekstra 1998; Fig. 1). Bears also caused property damage when seeking human foods and garbage in campgrounds and developments (Gunther 1994). The large number of human–bear conflicts prompted managers to remove a large number of bears (Fig. 1). In 1960 (National Park Service 1960) and 1970 (Leopold et al. 1969), YNP implemented increasingly intensive bear management plans to deal with the escalating conflicts (Table 1). The foundation of these plans was to make it much harder for bears to obtain human foods: all garbage dumps in the park were closed (all bear-viewing feeding stations had been closed by the early 1940s), all garbage cans and dumpsters were converted to a bear-proof design, and regulations prohibiting recreational hand-feeding of
Table 1. Periods of major changes in bear (*Ursus arctos, U. americanus*) management with respect to availability of human-related foods for bears in Yellowstone National Park, USA, 1931–2016. This evolution of policy in national parks set the pattern for reducing bear conflicts across North America.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Availability of human food and garbage for bears</th>
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bears were strictly enforced (Meagher and Phillips 1983; Fig. 2). Additionally, food-storage hanging poles or bear-proof food-storage boxes were installed in every backcountry campsite. The combined efforts of these front- and backcountry food and garbage storage programs were highly successful at preventing bears from obtaining anthropogenic food (Cole 1976, Meagher and Phillips 1983, Gunther 1994), which led to a sharp drop in conflicts (property damage and human injuries) and in numbers of bears removed (Fig. 1). These trends occurred concurrently with a growing bear population after the early 1980s (populations declined initially following dump closures).

These results from YNP were a compelling indication that property damage, human injuries, and the commensurate removal of bears were all directly related to the availability of human-related foods. Other national parks throughout North America reported similar results when implementing management programs designed to prevent bears from obtaining anthropogenic foods. Glacier National Park saw a notable reduction in bears killed (Gniadek and Kendall 1998). Denali and Yosemite National Parks observed significant declines in bear use of anthropogenic foods (Hopkins et al. 2014) and corresponding conflicts (Keay and Webb 1989, Schirokauer and Boyd 1998, Greenleaf et al. 2009). In the eastern United States, Great Smoky Mountains (B. Silver, personal communication, 2011) and Shenandoah National Parks (Garner and Vaughan 1989) reported reductions in bear-caused property damage, bear-inflicted human injuries, and the number of problem bears that had to be killed. Grizzly bear attacks on people in Banff, Jasper, Kootenay, Waterton, and Yoho National Parks in Canada also decreased with better food and garbage management techniques (Herrero and Higgins 1999). Likewise, state agencies in Wyoming (Teaschner and Boyce 2011), Montana (Frey and Smith 2013), and Idaho (Aber 2013) reduced human–bear conflicts in residential communities outside of Yellowstone National Park through implementation of programs centered on preventing bears from obtaining human foods and garbage, akin to the policies within the park.

The current philosophy of U.S. national parks is that biotic communities should be maintained in as near a primitive state as is practical, with minimal human influence and functional natural processes. Feeding of bears is unnatural and the behaviors of fed bears toward humans are unnatural as well as risky. Even without bear feeding stations and public recreational hand-feeding of bears, thousands of visitors still see bears in YNP annually, contributing toward building a public constituency that supports bear conservation (Gunther and Wyman 2008, Haroldson and Gunther 2013).

**Unintentional feeding in Aspen, Colorado**

The central premise of diversionary feeding is that bears will be attracted to the target food source because of the type, quantity, or accessibility of food, and hence be dissuaded from using other available anthropogenic food sources. We reasoned that if bears were drawn into a town because of poor natural foods in the surrounding natural habitats, lucrative dumpsters containing a concentration of human foods could lure them away from other anthropogenic foods that are less concentrated or closer to dwellings (and hence potentially riskier to obtain; Johnson et al. 2015). We used Global Positioning System (GPS) movement data and backtracked foraging
Fig. 1. Yellowstone National Park, USA, showed a decline in the incidents of bear-caused damage (top), bear-caused injuries to people (middle), and bears removed in conflict situations (bottom) from the period when human-related foods were readily available (1931–1959; see Table 1), to the transition period of removal of human-related foods (1960–1982), to the most recent period when human-related foods were not readily available to bears (1983–2012). Graphs show total raw numbers for each period (29, 23, and 30 yr duration, respectively) as lines (values on right axis) and values adjusted per million visitors within each period (grey bars, left axis). Data could not be separated for grizzly bears (Ursus arctos) and black bears (U. americanus).
Fig. 2. Graphic posters showing the dangers of feeding bears were used early in the campaign within U.S. national parks to teach visitors that feeding bears is a bad idea (from Special Committee on Conservation of Wildlife Resources 1940). Most state and provincial management agencies in North America have adopted (in modified form) this decades-long public educational effort against bear feeding, and for the removal of all attractants, as the principal means of controlling conflicts.

data from a 6-year study in Aspen, Colorado, USA, to test this expectation that bears will spend most of their time near and feeding on a few focal dumpsters.

The city of Aspen, located in the central Rocky Mountains in Colorado, is surrounded by deciduous forests and mountain-shrub vegetation communities that are considered among the most productive habitats for black bears in the state (Beck 1991). The city, with 6,700 residents, also has a large year-round influx of tourists attracted by opportunities for outdoor recreation, such as skiing and hiking. During 2005–2010, researchers from Colorado State University, U.S. Department of Agriculture - Wildlife Services - National Wildlife Research Center, and Colorado Parks and Wildlife collected detailed behavioral data on bear movement and foraging patterns in Aspen as part of an urban black bear ecology study (Baruch-Mordo 2014, Lewis et al. 2015). Study results revealed that (1) black bears used the town of Aspen as a food source when hard and soft mast production failed in the surrounding forest, (2) trash was the major anthropogenic attractant related to bear foraging in town, and (3) several dumpster locations served as point attractions frequently visited by bears (Fig. 3).

No diversionary feeding was conducted in Aspen; however, unintentional feeding at point attraction dumpsters provided large quantities of easily accessible and concentrated food sources akin to what might be provided in a deliberate diversionary feeding program. The focal dumpsters were identified from evidence of frequent bear use, based on regular (sometimes daily) sampling while monitoring the efficacy of education and enforcement efforts (Baruch-Mordo et al. 2011), and from backtracking individual bears to better understand their foraging choices (Lewis et al. 2015). Bears with GPS collars provided movement and foraging data that enabled testing of the hypothesis that concentrated food sources could lure bears away from other human-food attractants in their vicinity (including other residential trash containers, fruit trees, birdfeeders, etc.), and thus reduce conflicts elsewhere.

We recognize differences between a well-designed diversionary feeding and the unintentional feeding provided by these food sources; for example, intentional diversionary feeding would typically be in good bear habitat outside the area of human development. Also, the type of food used for diversionary feeding should not be the same as the food source from which bears are being diverted. While we acknowledge these limitations in this comparison, we also note that all focal dumpsters considered in this analysis were near good bear habitat (e.g., riparian areas, open space areas, or at the boundary of natural areas; Fig. 3). Furthermore, some dumpsters included very high-calorie foods (e.g., restaurant grease and meat) that seemed to appeal to the bears because they returned to those locations multiple times (which prompted our selection of these focal dumpsters). Still,
in light of these limitations, we did not consider this study a test of diversionary feeding, but rather a study of whether concentrated feeding sources in the vicinity of other attractants can lure bears away from conflict situations, which is the ultimate goal of diversionary feeding.

Movement data were collected at 30-minute intervals during 2007–2010. Only data collected from resident bears (n = 16) in May–September (the active season) were included in this case study. Bears did not use Aspen as extensively in years of good natural food production; therefore, movement data were summarized for all years combined (n = 22 bear-yr records for 16 unique bears) and for poor natural food production years (2007 and 2009; n = 15 bear-yr records for 12 unique bears). When bears ventured within 50 m of human development, we backtracked, on the ground, locations from the previous 24 hours to categorize types of activity and foraging (e.g., bedding sites, broken trash cans, human structures, branches, or logs) and recorded our degree of confidence in this categorization (Lewis et al. 2015). Only foraging events relating to anthropogenic feedings (e.g., feedings related to trash, restaurant grease, birdfeeders, barbeque grills, home or car break-ins) with high confidence categorization (n = 151 for 11 bears) were included in this case study.

Focal dumpsters were buffered with circular rings (hereafter, buffers) of 50–500-m radius. We note that
Fig. 4. Weighted mean (± 1 SE) proportion of black bear (*Ursus americanus*) locations and anthropogenic feeding events (e.g., related to trash, grease, birdberry, barbecue grills, home or car break-ins, etc.) that occurred within a buffer (see Fig. 3) around main dumpster attractant sites in Aspen, Colorado, USA. Movement data (locations of Global Positioning System–collared bears) with respect to the dumpsters were summarized for all years combined (2007–2010), and for poor natural food production years (2007 and 2009) when bears used the urban environment more extensively. Data were averaged across all bears and proportions were calculated from the total for each bear and year record.

although there was no biological rationale for selecting the maximum buffer distance, the total area enclosed by the maximum buffer of all locations (4.44 km<sup>2</sup>) overlapped 47% of the Aspen city boundary (9.36 km<sup>2</sup>) and included 65% of structures in the city (Fig. 3). The proportion of movement data and foraging events that occurred within each buffer were summarized for each bear as a function of total movement data and foraging events that were sampled for that bear while in Aspen. If focal dumpsters served as diversionary feeding sites for bears, then the proportion of movement and foraging data that occurred at or near (≤500 m) the focal dumpsters accounted for up to 20% of total sample locations within Aspen; these results did not differ significantly when data were summarized for all years or for poor natural food years (Fig. 4). On average across all bears, approximately 10% of confirmed anthropogenic foraging events occurred within 50 m of focal dumpsters (Fig. 4), indicating that the vast majority (90%) of feeding occurred elsewhere in Aspen. Only 40% (on average) of feeding events in Aspen were within 500 m of dumpsters, even though this area constituted the majority of the most developed urban area.

Both movement and foraging data from Aspen suggest that although bears used focal dumpster sites during years with poor natural food production, they still roamed widely throughout Aspen foraging on other available attractants and at times were involved in human–bear conflicts throughout town.

Tests of diversionary feeding in northern Minnesota

In contrast to the Aspen results, a study in northern Minnesota, USA, purportedly showed that black bears were diverted from using food sourcees around residences when provisioned with a high-quality alternative food (Rogers 2011). The study area was heavily wooded with a low human density that included scattered homes, summer cabins, and a campground. The investigator established a single feeding site at his field station, where he could observe, capture, radiocollar, and intentionally habituate black bears. He baited with unlimited amounts of beef fat during 1984–1985, and then limited amounts of beef fat during 1986–1991. He investigated reported conflicts in a 6.6-km stretch of residences and campsites on either side of the feeding station. No attempt was made to reduce other attractants in the area so as to singularly test diversionary feeding.

Rogers (2011) presented the following results as evidence that this feeding served to reduce conflicts. (1) Six bears were removed as nuisances during 3 years prior to the feeding (1981–1983) versus only 2 known removals during the 8-year feeding period (1984–1991); both bears that were removed during the feeding period had been new immigrants that had not fed at the feeder. (2) Nuisance bears were present at a nearby campground in the pre-feeding years, but no nuisance activity was reported there after feeding commenced in 1984 and 1985 (when natural food was very poor). (3) During some of the feeding years, reported conflicts with bears were high elsewhere in Minnesota.

However, a direct link between feeding and conflicts is not upheld by a critical scrutiny of these results. The difference in the number of bears killed during the pre-feeding versus feeding years is not only small, but
not clearly attributable to feeding. We reviewed records from the Minnesota Department of Natural Resources (MDNR) for the years that Rogers (2011) conducted his study and found the accounts of the 6 bears removed from his study area during 1981–1983: 4 were trapped and translocated in 1981, 1 was killed in 1982, and 1 was killed in 1983. These removals followed a diminishing trend in nuisance complaints recorded in Rogers’ study area north to the town of Ely (23 in 1981, 17 in 1982, 12 in 1983; MDNR, unpublished data). Additionally, during the years of this study, half or more of the nuisance bears killed in Minnesota were not reported, based on data from a co-occurring telemetry study (Garshelis et al. 1988).

Other than the killed bears, there was no documentation of changes in the extent of nuisance activity by bears or changes in human behavior relative to the bears. Rogers (2011: 293) noted that through the feeding, residents had an opportunity “to meet the bears that they feared and develop more tolerant attitudes.” This suggests that they either saw the bears being fed or had closer encounters with some of the fed bears that had become human-habituated. It thus appears that some local people became less apt to complain about a bear in the vicinity. Rogers (2011) noted a large number of bear complaints elsewhere in Minnesota, but this is not germane to this comparison. Despite thousands of complaints statewide, there must have been many 6-km stretches of road with residences where no bears were killed and no conflicts reported.

Finally, it is important to note that very few bears fed at this feeding site. Rogers reported that “the artificial feeding site was essentially discontinued in 1988 and 1989”: only 1 bear visited his feeding site in those years, and this bear’s use “was limited to a few visits each year in late May (after spring forbs became unpalatable but before ant pupae became abundant) and in early autumn (after berries and hazelnuts disappeared). On each visit, she was given a few grams of food to entice her onto a platform scale, and she was given more food during the autumn 1988 hunting season to divert her from any hunters’ baits and to increase the chance of her producing cubs” (Rogers and Wilker 1990:323). Whether this bear might have been more or less prone to seek foods at neighboring residences had it not been intentionally fed remains an open question, but the fact that this case was reduced to a single bear that was occasionally fed provides little support of diversionary feeding as a general management strategy.

A true test of the effectiveness of the feeding in diverting bears from other food sources would need to separately investigate the actions of bears from the actions and perceptions of people affected by the bears. Whereas it is interesting in this case that once they got to know individual neighborhood bears, people may have become more tolerant and hence less apt to report certain actions of the bears as conflicts, this is not an aim of diversionary feeding. Furthermore, judging the outcome of a feeding program requires that the investigator remains neutral (i.e., not influence the study subjects—in this case the local people); although education can increase tolerance and hence reduce conflicts, it can also confound the ability to decipher whether the feeding per se reduced the use of other food sources.

### Diversionary feeding trial in the Lake Tahoe Basin

In a 1-year emergency effort, food was provisioned around Lake Tahoe when natural foods became scarce in the surrounding forests and bears boldly sought foods from residences. Lake Tahoe is a natural water body in the central Sierra-Nevada Mountains in the arid southwestern United States, straddling the states of California and Nevada; droughts occur commonly in this area. The Tahoe Basin is ringed by >20 communities and 1 small city (South Lake Tahoe, population 21,000). Those communities are surrounded by vast, mountainous, largely undeveloped national forest lands dominated by pine (Pinus spp.) and inhabited by black bears. The primary mast species consumed by bears are manzanita (Arctostaphylos spp.), huckleberry oak (Quercus vaccinifolia), and Jeffrey pine (P. jeffreyi) nuts.

Anthropogenic foods have been available to black bears in the Tahoe Basin for decades, resulting in chronic food conditioning and habituation of >50 identifiable resident bears during any given year. Educational activities aimed at reducing human–bear conflicts have been conducted largely by the BEAR League (henceforth, League), a community-based, not-for-profit organization. The League also has maintained a bear conflict hotline. Since 2003, records have been kept on each report, and starting in 2007 records included the location of each conflict and details about the type of conflict and resolution.

During 2007 a severe regional drought eliminated most water sources in the Tahoe Basin other than the lake itself and its sole outflow, the Truckee River. As a consequence, the area also experienced a severe failure of natural bear foods. Although no quantitative assessment was made of mast production, virtually no manzanita berries or pine nuts were found by League members or agency biologists.
production, conflict levels tended to increase from May almost 60/day. During August 2007, conflicts reached 1,819–449–533) and 2 years after the drought (470; range = months during the 2 years before the drought (491; range = complaints of bears in yards (4,953) and inside homes During May–November 2007, the League received 7,885 number of registered complaints on the League hotline. When bears were no longer found, presumably because the bears had fall near the end of November, after which bear tracks were not uncommon. Two cases of minor injuries to people by bears were reported when bears entered residents' homes and the occupant unknowingly stood in the bear's path of escape.

As a last resort attempt to curb conflicts, the League had initiated a diversionary feeding program. Notably, in all other years, the League strongly advocated against any feeding of bears and consistently argued that conflicts are reduced when bears are unable to obtain anthropogenic foods. The diversionary feeding program was conceived, though, in response to a desperate problem, and was initiated without opportunity to obtain a research permit or document all relevant variables. It was not designed as a scientific experiment; however, sufficient data are available to warrant a post hoc examination of results.

The diversionary feeding program was conducted by League volunteers during September–November, 2007. Volunteers provided bears with >20 metric tons of organic fruit and nuts, which had been donated by orchards outside the area. Most feeding sites were established 1–2 km into the forest. All food was carried in by backpack, and was not placed in the same spot as previous bait so foot travelers would be less apt to encounter a bear. Hence, there was no record of how much food had been consumed. Moreover, baits were scattered about so multiple bears could feed. Fresh baits were distributed daily and, when doing so, volunteers reported seeing many bear scats. The program continued until the first heavy snowfall near the end of November, after which bear tracks were no longer found, presumably because the bears had denned.

The effectiveness of the effort was measured by the number of registered complaints on the League hotline. During May–November 2007, the League received 7,885 complaints of bears in yards (4,953) and inside homes (2,932), a 16–17-fold increase over the mean for the same months during the 2 years before the drought (491; range = 449–533) and 2 years after the drought (470; range = 346–595). During August 2007, conflicts reached 1,819–almost 60/day.

During years of normal precipitation and bear food production, conflict levels tended to increase from May to July, declined during August and September, and increased again in October or November. The increase in May to July conflicts coincided with metabolic shifts in the bears, changes in types of natural foods available, and increasing numbers of summer visitors in towns, with concomitant increases in availability of anthropogenic foods to bears. The decline in conflicts during August and September coincided with ripening of wild berries and nuts, and with the post–Labor Day (U.S. holiday, first Monday of Sep) decline in numbers of summer visitors. The late rise in conflicts during October and November likely was prompted by hyperphagia and the declining supply of mast as it fell to the ground and was consumed by other animals or rotted.

Conflicts during the 2007 drought year were much higher than normal in May and rose much faster, doubling by June, and more than quadrupling by August (Fig. 5). After the diversionary feeding started, conflicts dropped 11% (from 1,819 to 1,622) by the end of September and 54% (to 834) by the end of November. The pattern of decline from August to September was similar to normal years, but the continued decline through October and November was unique to this year.

It is difficult to distinguish, though, whether the decline in reported conflicts was due mainly to the provisioned food, or if other confounding factors played a part. For example, publicity about the extreme situation may have made people more likely to secure attractants or less likely to visit summer homes in this area. People experiencing conflicts with bears, or hearing about high levels of conflicts, are apt to change their behavior to avoid conflicts with or without any formal intervention by authorities (Baruch-Mordo et al. 2011). Additionally, it is important to recognize that records of reported conflicts made to the BEAR League may not include conflicts recorded by the wildlife state agencies and do not include incidents that were not reported; reporting rates can vary with the sheer number and type of situations and with perceived effectiveness of responses to reported conflicts (Baruch-Mordo et al. 2008, Howe et al. 2010). Also, some bears were captured and moved and others may have left the area to try to find food elsewhere. It is notable that, despite the feeding, the number of complaints in October and November was still at least an order of magnitude higher than in normal years across the area.

To better sort out effects of the feeding from other confounding variables, Stringham and Bryant (2015, 2016) separated conflict records for the 7 communities located approximately 1 km from the nearest bait pile versus 13 other communities that were 2–20 km from a bait pile. They reported that conflicts dropped precipitously for the
Fig. 5. Number of reported human–black bear (*Ursus americanus*) conflicts per month, averaged among communities (+ SD shown as error bars) around Lake Tahoe, California–Nevada, USA. Communities that had a diversionary bait pile within 1 km (close bait) during September–November 2007, when the area experienced a severe drought and food shortage for bears, showed a steep decline in reported conflicts during the baiting period. Communities with baits 2–20 km away (far bait) showed less decline in conflicts. All communities had small numbers of complaints for 2 years after the drought, when there was no baiting. (Figure is based on original data, adapted from Stringham and Bryant 2016.)

7 communities close to baits (hereafter, baited communities; 41% by the end of Sep, 93% by the end of Nov, compared with Aug), but more gradually for communities more distant from baits. Not only was the relative rate of change different between these 2 groups of communities, but the mean number of complaints was also strikingly different. In August, before the feeding, the 7 baited communities averaged >100 complaints whereas the 13 other communities averaged 20% fewer. By November, though, the baited communities were nearly back to normal-year conflict levels (<10), whereas the other group of communities still had exceedingly large numbers of conflicts (averaging >50; Fig. 5). If we can consider the 2 groups of communities equal in all other regards (i.e., assuming similar populations of people with similar habits, similar drought conditions, similar nearby bear populations), then the difference in conflicts should be attributable to the proximity of the bait; we cannot say with certainty, however, that the placement of the bait was not affected by other confounding variables, which may have affected the bears’ use of the area or inclination to seek food in town.

Notably, one common fear was not realized during this application of diversionary feeding: no aggressive actions were reported by bears toward anyone involved in this project or anyone that ventured near the feeding sites. In part, this may have been due to the fact that most bears in this area were already human-habituated.

A second common fear of diversionary feeding is that after finding provisioned food, the fed bears will return to the site looking for anthropogenic food in subsequent years. In this case, the number of reported conflicts in 2008 (*n* = 346) was 35% lower than in 2006 (*n* = 533), the year before feeding, suggesting that, across this broad region, the 2007 feeding did not entice more bears than usual to seek foods in communities when natural foods were normal. However, because bears were not marked or tracked, it was not possible to ascertain whether fed bears in 2007 were more prone or not to enter communities in later years.
Widespread diversionary feeding in Slovenia

Slovenia provides an example of diversionary feeding on a very broad scale, and in contrast to the Lake Tahoe case, feeding occurs every year no matter what the food conditions are in the natural environment. Slovenia is one of the most forested countries in Europe but has no real wilderness, and even the largest continuous forest areas are, from a bear’s perspective, relatively small (250–450 km²); they are densely covered by forest roads and surrounded by human settlements. Human–brown bear conflicts are frequent and include livestock (sheep) depredations, damage to crops and orchards, damage to beehives, and bears entering settlements (Jerina et al. 2015). Attacks on humans are rare, but strongly affect public perception and acceptance of bears (Krofel and Jerina 2012). Each year, on average, €104,500 (€200/bear in the population) of compensation is paid for bear-caused damage (Krofel and Jerina 2012) and 15 problem bears are removed (i.e., approx. 3.5% of the population; Krofel et al. 2012). The frequency of conflicts and management removals of bears increased considerably in the past 20 years (Jerina et al. 2015).

Feeding of wildlife is a widely applied management measure in Slovenia; it is used for a variety of purposes and target species, most intensively for ungulates and brown bears (Adamić and Jerina 2010). Feeding is used to mitigate human–bear conflicts (diversionary feeding) as well as for baiting by hunters and for monitoring of the bear population (i.e., as an index of trends in population size and fecundity; Krofel et al. 2012, Kavčič et al. 2013). Diversionary feeding is the principal non-lethal strategy for reducing human–bear conflicts (Krofel and Jerina 2012), and managers and a large segment of the public, including politicians, strongly believe the measure is effective. Other non-lethal measures of human–bear conflict mitigation are used infrequently, largely because of the strong belief in the efficacy of diversionary feeding. Feeding is very intensive over the entire bear range except in the vicinity of settlements (<1–2 km; to prevent luring the bears near people [Fig. 6]) and has been performed throughout the year, every year, in some sites for >100 years (Simonič 1994).

It is commonly believed in Slovenia that provisioning bears with carrion is especially effective in reducing livestock depredations by satisfying protein needs and diverting bears from pastures (Štrumbelj 2006, Kavčič et al. 2013). In the past, carrion feeding was mandated across the Slovenian bear range by the National Bear Management Strategy (Štrumbelj 2006). However, in 2004 the use of carrion was banned because of mad cow disease, in accordance with European Union (E.U.) regulations. In the same decade, sheep depredation by bears increased. This affirmed the belief among managers that carrion feeding had been effective and triggered demands that it should be reintroduced (Kavčič et al. 2013). In other E.U. countries faced with human–bear conflicts, bears are either intentionally fed or have access to feeding sites for ungulates (Apollonio et al. 2010). Several European countries still use livestock carrion for bear feeding (e.g., Croatia, Serbia, Bosnia, Romania; Kavčič et al. 2013), and some managers are promoting its future use in countries where feeding is currently banned (e.g., Sweden and Norway; Bischof et al. 2008).

Studies to assess effects of diversionary feeding in Slovenia were carried out in the Core Bear Protective Area (approx. 4,000 km²), where approximately 95% of the country’s 400–500 bears live. Brown bear densities within this core area are among the highest reported in the world, locally exceeding 40 bears/100 km² (Jerina et al. 2013). Forests are intermingled with agricultural fields and small settlements; from any given location, average distance to the nearest house is approximately 1 km and average human density is 28–42 people/km². Until the ban on carrion feeding in 2004, the National Brown Bear Management Strategy prescribed 1 carrion feeding site/60 km² (Kavčič et al. 2013). Additionally, bears have had constant access to ungulate feeding sites provided with corn (14–23/100 km²). The amount of supplemental carrion varied from 33 to 146 kg/km² and the amount of supplemental corn from 70 to 280 kg/km² (Kaczensky 2000, Kavčič et al. 2013). Here we summarize results of studies that investigated (1) whether carrion diversionary feeding was effective in reducing sheep depredation, and (2) whether corn diversionary feeding diverted bears from human settlements.

The studies found no evidence that bears selected carrion feeding sites over sites with corn. Also, when controlled for changes in bear and sheep numbers, there was no indication that the ban on carrion feeding increased sheep depredations (Kavčič et al. 2013). Moreover, data on bear nutrition (Kavčič et al. 2015) indicated that natural protein sources were considerably more important to bears than livestock carrion and that use of carrion peaked in spring, when sheep were rarely outdoors and thus unavailable for depredation.

To assess whether feeding bears corn diverted them from human settlements, Jerina et al. (2012) monitored GPS-collared bears (n = 33) of both sexes and all age categories except cubs. Collars recorded a GPS fix every hour and activity every 5 minutes. In 25 bear-years of...
Fig. 6. Distribution of automatic corn feeders used by brown bears (*Ursus arctos*) and ungulates across Slovenia (data from 2014, although sites are rather permanent). Red outlined area is the core study area occupied by 95% of the country’s bears and where data were collected on Global Positioning System–collared bears.

monitoring, >100,000 GPS locations and nearly 1.5 million activity events (active or resting; Gervasi et al. 2006) were recorded. Bears were considered to be at a corn feeding site if within 140 m and were considered to be at a human settlement if within 180 m (Kavčič 2016). Data collection and analyses are further described in Jerina et al. (2012, 2013, 2015) and Kavčič (2016). Effects of feeding on bear occurrence in settlements were analyzed for several time frames (1 day, 1 week, 1 month, duration of monitoring) using the data from the entire year, and separately for each season (spring: Mar–May, summer: Jun–Aug, autumn: Sep–Nov, winter: Dec–Feb).

All GPS-collared bears used feeding sites. Excluding the denning period, they spent an average of 7% (individual range = 1–20%) of their time (12% of active time) at feeding sites. The GPS-collared bears spent, on average, <2% (range = 0–9%) of their time in or near (<180 m) settlements; while there (and elsewhere in Slovenia), they were nocturnal, indicating that they still feared people. Several bears visited both feeding sites and settlements during the same night. No correlation was observed between frequency of use of feeding sites (at any time scale) and bear occurrence near human settlements for analyses based on yearly, winter, spring or summer data. However, during autumn the frequency of use of feeding sites was inversely related to frequency of bear occurrence near settlements (Spearman’s $r = -0.49$, $n = 26$, $P = 0.01$).

Results suggest that feeding reduced the time spent in or near settlements by some bears during autumn hyperphagia, when a disproportionate (42% in 3 months; Jerina et al. 2015) incidence of conflicts with bears occurs in Slovenia. There was no evidence that such feeding increased habituation to people (Kavčič 2016), a concern raised from studies elsewhere (Herrero 1985, Gray et al.)
bears routinely fled when people approached feeding sites. An alternate explanation for the inverse relationship between time at feeders versus time in settlements (in autumn) is that the bears that spent less time in settlements feared people more, but took advantage of feeding sites that were more distant from human habitation; that is, the study did not directly investigate changes in bear behavior attributable to feeding. However, a fine-scale (1 × 1-km) country-wide spatial analysis indicated that human–bear conflicts were less prevalent where feeding was most intense after taking into account effects of bear density, availability of natural foods, and other factors that promote conflicts (e.g., vicinity of settlements, mixed forest–agriculture land use; Jerina et al. 2015).

Several other consequences of these feeding studies are worth noting. Before the carrion ban, provisioned food comprised 34% (corn 22%, carrion 12%) of the annual dietary energy content ingested by Slovenian brown bears (based on undigested remains in >700 scats, corrected for consumed biomass as per Hewitt and Robbins [1996]), and as high as 73% in some seasons and areas (Kavčič et al. 2015). Bear reliance on provisioned food in Slovenia is one of the highest reported anywhere (see Kavčič et al. 2015 for overview). Bears gained 3.9 × more energy per time unit spent at feeders than in natural habitats (Jerina et al. 2012). This increased energy gain likely increased body condition, which probably contributed to their very high reproductive rates (Krofel et al. 2012) and population densities (Jerina et al. 2013). The high reproductive potential and low natural mortality triggered a demand for more population control (up to 20% of population is culled annually; Krofel et al. 2012) because the current management goal is to prevent a population increase. Feeding may also be the reason for shorter and frequently interrupted denning of bears in Slovenia (Krofel et al. 2017) and other nearby European countries (e.g., Slovakia), where bears can obtain corn from ungulate feeding stations year-round (Štoffl et al. [2016]; but see Skuban et al. [2016], who found that corn was far less important than natural mast in affecting winter activity of bears in another part of Slovakia). Finally, feeding also affects interactions of bears with other species; for example, the presence of a bear feeding site increased by 5-fold the likelihood of lynx (Lynx lynx) losing its captured prey to bear kleptoparasitism (Krofel and Jerina 2016).

Discussion
The underlying premise of diversionary feeding—that bears can be lured away from conflict situations by provisioning an attractive food—makes intuitive sense, recognizing that bears are highly motivated by concentrated food sources. Often, bears become involved in conflict situations because of the allure of high-calorie human-related foods. Feeding on such foods entails heightened risks and costs; thus, bears must overcome their normal wariness of humans or adjust their activities to attempt to avoid humans, both likely indicative of the caloric rewards they receive (Ordiz et al. 2011, Baruch-Mordo et al. 2013, Malcolm et al. 2014, Ditmer et al. 2015, Johnson et al. 2015). American black bears and brown bears are especially adaptable opportunists that will supplement their normal diet with human-related food sources as necessary or as it befits them.

Bears normally subsist on wild foods that are small, scattered, and patchy, varying unpredictably spatially and temporally (Welch et al. 1997, Garshelis and Noyce 2008). They routinely experience booms and busts in food supplies lasting a few weeks or a whole active season. Being highly mobile with an extraordinary sense of smell, and with the ability to exploit cues from other bears, they are adapted to finding concentrated food sources from great distances (Davis et al. 2006, Noyce and Garshelis 2014). These characteristics suggest that humans should be able to manipulate the behaviors of bears by provisioning food in key locations. Two of the case studies that we investigated measured bear behavior as a response variable to provisioned food (Table 2). In one case (Aspen), where concentrated provisioned food (garbage in dumpsters, including grease and restaurant food) was similar to the attractant around homes, there was no evidence of it diverting a high proportion of bears. In the other case (Slovenia), the provisioned food was concentrated and different from that found in nearby communities, and also located in an area that a bear would not associate with people; here, during hyperphagia, some bears were apparently enticed to feed on provisioned food instead of within settlements. Notably, though, whereas the feeding seemed to reduce the time that they spent in settlements, many bears still went there. In both of these cases, the provisioned food was found reliably at the same locations, so bears would be spared search costs that could entail risky interactions with people. That some bears nevertheless continued searching near people suggests that they sought out (and likely found) higher quality foods; another possibility is that some bears were deterred from feeding sites because of conflicts with other bears. The Minnesota case used high-quality food (beef fat), but was conducted at too small a spatial scale and involved too many confounding variables (especially changes in people’s tolerance toward
Table 2. Comparison of methods and results of the bear (*Ursus arctos, U. americanus*)-feeding case studies examined herein.

<table>
<thead>
<tr>
<th>Study site</th>
<th>Purposeful diversionary feeding?</th>
<th>Duration of feeding</th>
<th>Type of food</th>
<th>Spatial scale</th>
<th>Variable(s) measured</th>
<th>Results</th>
<th>Successful diversionary feeding?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellowstone NP, USA</td>
<td>Secondary objective</td>
<td>Decades</td>
<td>Varied anthropogenic</td>
<td>Parkwide (8,990 km²)</td>
<td>Property damage, human injuries, number of bears removed</td>
<td>Conflicts reduced after feeding stopped</td>
<td>No</td>
</tr>
<tr>
<td>Aspen, Colorado, USA</td>
<td>No</td>
<td>Many years</td>
<td>Garbage</td>
<td>1 city</td>
<td>Bear movements</td>
<td>No evidence of reduced use of other human foods</td>
<td>No</td>
</tr>
<tr>
<td>Northern Minnesota, USA</td>
<td>Yes</td>
<td>8 yr</td>
<td>Beef fat</td>
<td>Homes along 6-km road</td>
<td>Reported conflicts, bears killed</td>
<td>Inconclusive because of confounding variables and small spatial scale</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>Tahoe Basin, California–Nevada, USA</td>
<td>Yes</td>
<td>3 months (drought)</td>
<td>Fruits and nuts</td>
<td>20 communities</td>
<td>Reported conflicts</td>
<td>Communities close to bait sites experienced reduced conflicts</td>
<td>Yes</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Yes</td>
<td>Decades</td>
<td>Corn</td>
<td>4000 km² (95% of bear range)</td>
<td>Bear movements, reported conflicts</td>
<td>In autumn, bears that spent more time at feeding sites spent less time in human settlements; conflicts less where feeding most intense</td>
<td>Probably</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Yes</td>
<td>Decades</td>
<td>Carrion</td>
<td>4000 km² (95% of bear range)</td>
<td>Bear nutrition, sheep depredation, bear use of feeding sites</td>
<td>No effects of ban of carrion feeding on sheep depredation</td>
<td>No</td>
</tr>
</tbody>
</table>
bears, and hence a shifting definition of a conflict) to assess whether bears were truly diverted from other attractants (Table 2).

The Tahoe Basin case, although not designed as a formal study, provided evidence that provisioned food may have diverted a substantial number of bears and reduced conflicts. Overall, despite the feeding, conflicts persisted at very high levels across the region—well above the norm—but a very sizeable reduction of conflicts was observed in those communities where diversionary food was nearby (Fig. 5). Two key aspects of this case deserve to be highlighted: (1) it occurred during a widespread food failure, when the primary motivation for bears entering communities was severe hunger; and (2) high-quality food, akin to natural food (fruits and nuts), was deployed outside the conflict area but assumed near enough to “intercept” approaching bears. The food piles were new, rather than sites well-known to the bears as in Slovenia, so it is not surprising that feeding sites close to the communities were more effective at intercepting bears approaching the communities.

In sum, the type and/or quality of provisioned food, its location with respect to the potential conflict area, the timing and/or frequency of feeding, and the abundance of other foods (both natural and anthropogenic) on the landscape may determine whether bears find and use diversionary food, and whether this is sufficient to reduce their attraction to other human-related foods (Table 2). Indeed, the most well-known and highly successful example of diversionary bear feeding employs nutritious food to lure bears away from stripping bark in managed forests in the Pacific Northwest of North America (Ziegler et al. 2004, 2006, 2008). In that situation, the pelleted food was far superior to the cambium that the bears were eating, and may have functioned as supplemental food to improve nutrition at a time of year when natural food was scarce. The Tahoe Basin and the Pacific Northwest cases indicate that diversionary feeding with high-quality foods has the potential to reduce human–bear conflicts that are driven by scarcity of natural foods. Likewise, the Slovenia case showed that diversionary feeding may be effective at times of year when bears are most motivated by a need to gain weight, especially when natural food is in short supply. The level of human–bear conflicts in Slovenia was inversely correlated with annual beechmast (Fagus sylvatica) production, and bear use of diversionary feeding sites also notably increased in autumn in years with poor mast production (Jerina et al. 2015). It has yet to be shown that diversionary feeding can reduce conflicts for bears that seek anthropogenic foods when adequate natural foods are available in the forest or at times of year when they are less food-driven. The reason for their attraction to human-populated areas in these circumstances is still not adequately understood, but appears to relate to a combination of bears viewing humans as a source of foods, learning from their mother, social factors, and a biological drive to gain mass quickly (Mazur and Seher 2008, Beckmann and Berger 2003a, Hopkins 2013, Merkle et al. 2013, Elfström et al. 2014c, Ditmer et al. 2016, Morehouse et al. 2016). If proximity of bears to people is more of a manifestation of the social relationships of bears than availability of foods, as some have asserted (Elfström et al. 2014a, b; Steyaert et al. 2016), then the conceptual connection between food provisioning and conflicts is less clear. For example, the spring breeding season may have been more a factor than hunger in the use of settlements by Slovenian bears, thus explaining why feeding stations did not deter them at that time of year.

Kubasiewicz et al. (2016) recently reviewed factors related to the success of diversionary feeding programs across varied taxa. They stressed the importance of understanding the biology and behavior of the species. For temperate bears, which spend ≥50% of the year losing weight (during and immediately after hibernation), energy maximization during feeding is paramount, and is reflected in feeding strategies (e.g., seeking concentrated foods and mixed diets, high-grading; Seger et al. 2013, Coogan et al. 2014, Erlenbach et al. 2014); thus, it is not surprising that food type and hunger levels would be important considerations in diversionary feeding. However, it is equally important to recognize that bears are powerful and potentially dangerous animals that can readily habituate to people, so feeding can have severe negative consequences as well.

Recognized negative consequences of feeding is what led to the eventual bans in U.S. national parks. The data clearly show that these feeding bans greatly reduced conflicts (Fig. 1). Moreover, following this example, it has now become standard policy for agencies responsible for managing human–bear conflicts to stress the removal of all attractants and discourage (or prohibit) the feeding of bears. This strategy is now almost universally accepted as the first line of action to mitigate conflicts with bears in North America. It is not only effective in most cases (including Tahoe in normal food years), but is appealing on an ethical level because bears are simply encouraged to live naturally with minimal human interference or control. Whereas repercussions of feeding—including fatter bears with higher reproduction (Dobey et al. 2005, Mansfield 2007) using smaller home ranges and different habitats (Beckmann and Berger 2003b, Massé et al. 2014)—
may not adversely affect their population, many would agree that altering natural behavior is itself an undesirable consequence of feeding, especially for bears, which tend to convey an image of wildness. We note, however, that this view is not universal and differs between North America and Europe. In Europe, large natural areas are a rarity and bears live much closer to people (Chapron et al. 2014). In several European countries, diversionary feeding is accepted as a necessary means by which bears can live near people (i.e., the price paid for coexistence).

Standard strategies of keeping bears away from attractants may be insufficient when attractants cannot be secured (e.g., cropfields, livestock, personal gardens, and orchards) or when bears are unusually hungry (i.e., during severe natural food shortages) and thus determined to find alternate sources of food. This is where diversionary feeding may become useful. However, managers contemplating this strategy should also be aware of potential side-effects. For example, long-term, widespread feeding—as has occurred in Slovenia—likely contributed to increased bear densities; so, although it seasonally diverted bears from conflicts on an individual level, it may have increased conflicts on a population level (bear density was a stronger positive predictor of conflicts than density of provisioned food was a negative predictor; Jerina et al. 2015). This situation is even more complex when extended to human attitudes and behaviors: high bear densities cause more conflicts but also allow more hunting opportunities, which is likely viewed as a positive attribute (Majić et al. 2011). A meta-analysis of conflict claims within all European countries with populations of brown bears suggested that feeding programs were associated with fewer claims, although those countries with feeding programs also had a longer history of coexistence with large carnivores, so the actual effect of feeding is somewhat equivocal (Bautista et al. 2016).

One of the most feared consequences of diversionary feeding is that fed bears might become less wary of humans and more attracted to other foods near humans, thus creating even more conflicts. This apparently occurred in Yosemite National Park: what began as an attempted diversionary feeding program to lure bears away from visitors resulted in more and more bears seeking human-related foods, visitors feeding these food-conditioned–behavioral bears, respectively. The Minnesota case used especially attractive bait, but also intentionally habituated the fed bears to people so they could serve as future study subjects (Rogers and Wilker 1990). The number of fed bears in this case was so small, and records on their behaviors around people not clearly identified, so the effects of this feeding remain equivocal. However, in a much larger feeding effort by the same researcher, neighbors complained of particularly bold bears approaching them and seeking food, which ultimately convinced a court to rule that the feeding constituted a public safety risk (Office of Administrative Hearings 2014). Although the researcher argued that this was an example of diversionary feeding—used to find alternate sources of food. This is where diversionary feeding may become useful. However, managers contemplating this strategy should also be aware of potential side-effects. For example, long-term, widespread feeding—as has occurred in Slovenia—likely contributed to increased bear densities; so, although it seasonally diverted bears from conflicts on an individual level, it may have increased conflicts on a population level (bear density was a stronger positive predictor of conflicts than density of provisioned food was a negative predictor; Jerina et al. 2015). This situation is even more complex when extended to human attitudes and behaviors: high bear densities cause more conflicts but also allow more hunting opportunities, which is likely viewed as a positive attribute (Majić et al. 2011). A meta-analysis of conflict claims within all European countries with populations of brown bears suggested that feeding programs were associated with fewer claims, although those countries with feeding programs also had a longer history of coexistence with large carnivores, so the actual effect of feeding is somewhat equivocal (Bautista et al. 2016).

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The other diversionary feeding case studies that we reviewed did not indicate that feeding caused more problems, but this remains an open question. For example, many of the Tahoe bears were already food-conditioned, and no information was available as to whether the intentional feeding during the drought year exposed some new bears to human foods, which afterward may have sought such foods more readily. Likewise, we cannot tell whether the bears in Aspen or Slovenia would have been less inclined to consume human-related foods had they not been exposed to dumpsters and corn or carrion baits, respectively. The Minnesota case used especially attractive bait, but also intentionally habituated the fed bears to people so they could serve as future study subjects (Rogers and Wilker 1990). The number of fed bears in this case was so small, and records on their behaviors around people not clearly identified, so the effects of this feeding remain equivocal. However, in a much larger feeding effort by the same researcher, neighbors complained of particularly bold bears approaching them and seeking food, which ultimately convinced a court to rule that the feeding constituted a public safety risk (Office of Administrative Hearings 2014). Although the researcher argued that this was an example of diversionary feeding.
feeding, the food was provided within a community, next to a house, and often by hand or at least when people were present, so the bears became highly habituated to people and numbers of bears in the community increased exponentially.

Another fear of feeding is that, once started, it cannot easily be stopped because bears become dependent on human-sourced foods. The Tahoe Basin case study showed no evidence of this. The year following the drought-motivated feeding program, it appeared that most bears returned to normal feeding patterns, judging by a return to normal levels of reported conflicts. Likewise, the year following a food failure in Minnesota that prompted many bears to feed at an open-pit dump, radiocollared bears returned to natural feeding patterns (D.L. Garshelis, unpublished data). Conversely, the Yellowstone NP case clearly showed that perpetual feeding does cause some bears to become reliant on human food: when the dumps were closed and feeding prohibited, a large number of food-conditioned, human-habituated bears became problematic and had to be killed (Craighead et al. 1995).

**Recommendations**

In assembling this review using all of the studies that we could find, it has become clear that there is yet a dearth of information and hence considerable controversy as to whether diversionary feeding is an effective tool for reducing conflicts with bears near human development. Variability in the methods and results of our case studies (Table 2) helped elucidate some tentative findings, but at the same time hampered making strong inferences. At least until such time that more is known, we suggest that if diversionary feeding is to be used, it should be a well-organized effort overseen by professionals, not an ad hoc effort of a local organization or community that may be tempted to feed bears in the hopes of preventing them from being killed by authorities. Further, we agree with Kubasiewicz et al. (2016) that the significant variability among methods and circumstances calls for an adaptive management approach to gradually improve outcomes of diversionary feeding. As such, we recommend that any such effort be conducted as an experiment rather than simply an emergency management action. In that respect, it would be highly beneficial to ensure that the correct response variables are measured (e.g., types and number of conflicts, amount of damage [see Kubasiewicz et al. 2016]) and careful documentation is made of all pertinent variables (e.g., availability of natural foods; types, quantities, nutritional content, location of provisioned food; number of bears utilizing the food [see Herreman and Peacock 2013]; amount of food consumed by bears [see Lewis et al. 2017]; documentation or monitoring of identifiable individual bears at feeding stations and at conflict sites; availability and use of other human-related foods; concurrent educational efforts; bear population trends and management removals; etc.). Additionally, it would be beneficial to include a control site to separate the effects of the treatment (feeding) from the unavoidable confounding issues that are likely to arise, and monitor areas for prolonged periods of time to capture the periodicity of natural food (i.e., multiple good and poor food years). Having said that, we recognize that current situations sometimes do not allow for establishing control sites. For example, because Slovenia uses feeding as an official management measure, it occurs across the landscape (Fig. 6) and likely could not be stopped for the purpose of conducting a study; hence, the spatial variability in the intensity (density) of feeding was used instead of a non-feeding control (Jerina et al. 2015). Likewise, in Tahoe Basin, the communities with baits > 1 km away were useful reference sites, although not true controls.

Until such time that this technique is adequately tested and evaluated in terms of effectiveness, cost-benefit, and side-effects, it will be a basis of contention among those who view it as an appealing and logical technique with some tantalizing results, versus those (predominantly in North America) who perceive many downsides of feeding and fear that opening this door may reverse what has been a decades-long, hard-fought campaign to convince the public that a fed bear is more likely to be a dead bear.

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