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ARE DESERT BASINS EFFECTIVE BARRIERS TO MOVEMENTS OF RELOCATED BLACK BEARS (*URSUS AMERICANUS*)?

Jon P. Beckmann[1,2,3] and Carl W. Lackey[4]

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During the last 10–20 years many areas have experienced an increase in number of conflicts between black bears (*Ursus americanus*) and humans, and such an increase in conflicts has been disproportional to human population growth. This is especially true in western North America, where rapid urban sprawl has led to encroachment into areas adjacent to U.S. public lands that have historically contained large carnivores. For example, from 1990 to 2000 the human population in the Lake Tahoe basin increased by 26% and the number of complaints by citizens concerning black bears increased by more than tenfold during the same time period (Goodrich 1990, Beckmann 2002). In Nevada, as in other areas of western North America, human–bear interactions have included loss of pets, localized predation on livestock, property damage, and even human deaths (approximately 45 deaths from black bears since 1900 in North America; Herrero 2002).

Many state and federal entities seek nonlethal solutions (i.e., relocation or deterrents) for dealing with "nuisance" carnivores, especially black bears. Yet there is a paucity of rigorous study on the effectiveness of the most common nonlethal techniques management agencies currently use to alter the behavior of nuisance bears, although exceptions clearly exist (e.g., Gillin et al. 1994, Tement and Garshelis 1999, Clark et al. 2002). A survey conducted by the Virginia Department of Game and Inland Fisheries in 2001 revealed that 33 states, including Nevada, currently manage black bears and respond to citizen complaints about nuisance bears (D. Kocka, Virginia Department of Game and Inland Fisheries, personal communication). Of those states, 26 relocate bears with the aim of removing nuisance individuals.

We capitalized on the extent to which desert basins separate the Sierra Nevada and adjacent Great Basin ranges to examine the effectiveness of relocation efforts. The Great Basin Desert represents a unique opportunity to evaluate the efficacy of relocation of nuisance bears because desert floors, which can be greater than 64 km wide, separate mountain ranges where bears occur. Further, desert basins are often large areas of unsuitable desert habitat (e.g., large expanses of sagebrush [*Artemisia* spp.]) that bears do not use (Goodrich 1990, Beckmann 2002, Beckmann and Berger 2003). However, bears will occasionally make relatively short movements through areas consisting of sagebrush in order to reach patchily distributed suitable habitat (e.g., cone-producing trees) in this arid landscape. Thus, we wanted to test whether these expansive desert basins could prohibit movements of relocated bears between mountain ranges.

The current distribution of black bears in Nevada is restricted to extreme western portions of the state in the Carson Range of the Sierra Nevada, and in the Sweetwater, Pine Nut, and Wassuk Ranges (Goodrich 1990), which are areas with high peaks and deep canyons (Grayson 1993); these ranges were the focus of our work. We utilized urban areas in western Nevada such as Reno, Carson City, Incline Village, Glenbrook, Stateline, Minden, and Gardnerville, when capturing urban-interface bears. Bears in this region are at the edge of their known range in the Great Basin, with the nearest eastern bear population found in the Wasatch Range, Utah, about 750 km away (Goodrich 1990). Although black bears

[1]Program in Ecology, Evolution, and Conservation Biology, University of Nevada, Reno, NV 89512.
[2]Department of Environmental and Resource Sciences, University of Nevada, Reno, NV 89512.
[3]Wildlife Conservation Society, Teton Field Office, Moose, WY 83012.
[4]Nevada Division of Wildlife, 1100 Valley Road, Reno, NV 89512.

are listed as a game species in Nevada, there has never been a legal harvest.

We captured bears by using culvert traps and hounds from 1 July 1997 to 1 April 2002. We tranquilized and weighed the bears and attached radio-collars with mortality sensors (Advanced Telemetry Systems, Isanti, MN; see Beckmann 2002 for details) to individual bears. Age was estimated from annuli of the 1st upper premolar (PM_1), the standard tooth for age analysis in black bears (Matson's Laboratory, Milltown, MT; Stoneberg and Jonkel 1966). Animals were classified as cubs (<1.5 years), juveniles (1.5–3 years), or adults (≥3 years).

To examine whether desert basins serve as effective barriers to movements of relocated black bears, we selected 8 adult (≥3 years) male bears from a total of 71 bears that were captured inside urban areas and relocated them to different mountain ranges. Relocation was defined as an individual being moved ≥25 km from its capture site to a release site in a mountain range different from the one in which it was captured. In each case bears were relocated to sites that had a known bear population based on telemetry studies at the time of release (Beckmann 2002). We relocated only adult male bears for several reasons: (1) 93% of all adult bears captured in urban centers in the Lake Tahoe basin and the western Great Basin were males, (2) females often had cubs and we did not want to heighten mortality risks to cubs via additional travel that might include crossing roads, and (3) we eliminated both sex and various age categories (i.e., juveniles and cubs) as confounding factors when analyzing our results. Additionally, because of cost constraints and public relations reasons, we were allowed to relocate only 10% of bears captured in urban areas by the Nevada Division of Wildlife (NDOW).

The 8 bears were moved varying distances between their point of capture in urban centers and the target mountain range for relocation (see Table 1 for distances). Of the 8 individuals, 2 (#34, 56) were relocated in the spring (March–May), 3 (#2, 19, 36) in summer (June–August), and 3 (#24, 25, 26) during fall months (September–November). Once a bear was relocated, we followed the individual using telemetry to determine its location and to monitor the rate of return to the initial capture region. Animals were located, weather permitting, from a Cessna 206 fixed-wing airplane and from the ground. We assigned Universal Transverse Mercator (UTM) coordinates to each location from a GPS unit onboard the aircraft or from standard triangulation methods (Heezen and Tester 1967, Hupp and Ratti 1983, Samuel and Fuller 1994) on the ground. Locations for each relocated individual were mapped using ArcView 3.2 software. Telemetry points were recorded from the air every 3 days for each individual until their return. However, once a bear was within 5 km of the urban center from which it was originally captured, we located the bear every day to determine the exact date of return. A bear was considered to have returned the 1st time it was located inside the city limits from which it was captured, as defined on coverage maps from the year 2000 in ArcView 3.2. We also estimated the total distance (km) of unsuitable sagebrush (*Artemisia* spp.) and agricultural habitats in basins (using vegetation coverage maps in ArcView 3.2) that a bear had to cross to return to its original point of capture (Table 1). Some bears had to cross several basins of unsuitable habitat to return. For these individuals we estimated the minimum distance of inappropriate habitat that the bear had to cross in each basin and then summed these values for total distance.

We used Pearson correlation (r) analyses to test for relationships between the period of time that elapsed (days) before a bear returned and the distance (km) the bear was moved, the weight (kg) of the relocated bear, and the age (years) of the relocated bear (SAS 2001). A probability level of $P < 0.05$ was used for all statistical tests. Means ± 1s are given unless otherwise noted.

The mean distance that all 8 adult male bears were moved was 58.6 km ± 27.4 km (Table 1). Of the 8 relocated animals, all returned to the urban center where they were captured within 18 days (Table 1). In all 8 instances the bears remained at the relocation site for at least 1 night before moving, regardless of the time of day the bear was released. The mean number of days for all bears to return was 15.1 ± 2.2 (Table 1). The period of time for a bear to return to the urban site of capture was not correlated with distance that an individual was moved ($r = 0.44$, df = 6, $P = 0.2713$) nor with its mass ($r = -0.15$, df = 6, $P = 0.7148$) nor with its age ($r = -0.22$, df = 6, $P = 0.6058$). No individuals died during their movements from the release site to the

TABLE 1. Summary of 8 collared adult (≥3 years) male black bears (*Ursus americanus*) relocated from urban areas to a different mountain range at the interface of the Sierra Nevada (Lake Tahoe basin) and the western Great Basin Desert. Relocation was defined as an individual being moved ≥25 km from its point of capture to a different mountain range within the Great Basin Desert. Age was estimated from annuli of the 1st upper premolar (PM_1). Total unsuitable distance (km) is the distance of unsuitable sagebrush (*Artemisia* spp.) and agricultural habitats that a bear had to cross to return to its original point of capture. Six (#2, 24, 25, 26, 34, 56) bears had to cross ≥2 basins of unsuitable habitat in order to return. Means ± 1s are given.

ID #	Age	Weight (kg)	Distance relocated (km)	Total unsuitable distance (km)	Days elapsed until return
2	9	154	76.8	32	15
19	9	191	25.6	16	12
24	10	200	65.6	32	15
25	5	82	43.2	28	14
26	9	186	104	64	18
34	3	84	76.8	35	16
36	3	73	25.6	16	18
56	5	100	51.5	25	13
Mean	6.6 ± 2.9	133.8 ± 54.5	58.6 ± 27.4	31 ± 15.1	15.1 ± 2.2

original capture site despite the fact that in all cases bears had to cross either U.S. Highway 395 or U.S. Highway 50, and in some cases both 4-lane highways in western Nevada to return to their original home range. However, in 2 instances (#56 and #19) relocated bears were hit by vehicles that had slowed down enough to prevent serious injury to either the bear or people inside the vehicles. Both incidents occurred on 2-lane, mountain highways crossing the Carson Range of the Sierra Nevada from the Great Basin Desert into the Lake Tahoe basin.

Results of this study indicate that relocation of nuisance bears is not an effective management option for reducing the number of negative interactions between bears and humans, at least in the Lake Tahoe basin and adjacent Great Basin Desert ranges. Additionally, based on our sample, desert basins are ineffective barriers to movement of bears from one mountain range to another, even for time periods <2 weeks. Even bears that were relocated across multiple desert mountain ranges and basins (n = 6) or >100 km (n = 1) from their original mountain range of capture returned. Although our sample sizes are small within a season, it appears that time of year did not impact the rate at which relocated bears returned to their original location of capture. It is unlikely that a lack of potential mates in release sites influenced a male bear's homing tendency, given that radio-collared adult females were present at each release site during this study (see Beckmann 2002). Surprisingly, the distance that bears were moved was not correlated with the amount of time it took an individual to return to the original site of capture. This was likely because of the relatively small distances that we were able to move bears (<105 km in all cases), given the limited habitat suitable for bears in the xeric climate of the western Great Basin. Further, we did not want to move any bears to mountain ranges in which they had not historically occurred, thus limiting the maximum distance that we could relocate any bear.

The vehicle strike rate for collared bears that were not relocated during this study was 17%. The fact that two (25%) relocated bears in this study were struck by vehicles during their efforts to return to their point of capture further suggests that relocation may ultimately have a negative impact on populations. This is especially true if agencies are relocating female bears with cubs, assuming that females also would attempt to return to their original home range in a manner similar to males. However, given that males have a greater tendency to move long distances, the impacts of long-distance relocation on females and cubs may be different—an issue that awaits further investigation from biologists.

Because of conservation concerns associated with the current high levels of mortality of bears in urban areas from negative interactions with humans in this region, where <300 bears occur (Goodrich 1990, Beckmann 2002), we examined relocation as a potential nonlethal tool to reduce bear and human conflicts.

because relocation is not an effective management option, at least in western Nevada, we suggest that to protect bears at the interface of the northern Sierra Nevada and the western Great Basin, including the Lake Tahoe basin, ordinances and laws requiring the use of bear-proof dumpsters are badly needed. Good planning and subsequent management, based on a combination of life history and ecological data, will continue to be an obvious requisite action to ensure the persistence of a species dependent on profitable foraging in human zones. Once this can be achieved, especially in areas outside national parks where legal compliance that favors biodiversity tends to be weaker, our ability to assure the persistence of this large carnivore on U.S. public lands will improve.

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