Survival of nuisance American black bears released on-site in Great Smoky Mountains National Park

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Abstract: Since 1990, wildlife biologists in Great Smoky Mountains National Park (GSMNP) have used capture and on-site release as the primary management technique to reduce recurrence of nuisance activity by American black bears (*Ursus americanus*). On-site release involves the capture and immobilization of bears that frequent developed areas, collection of biological data, and subsequent release in the area of capture. Although several studies have documented the effectiveness of this technique to reduce recurrence of nuisance activity, survival of bears after on-site release has not been thoroughly examined. We monitored 17 black bears (9 males and 8 females) that were radiocollared and released on-site in GSMNP between May 1997 and December 1998. We estimated short-term survival (May–Dec) using the Kaplan-Meier staggered entry procedure. Survival of black bears released on-site in GSMNP was 0.88 (95% CI = 0.70–1.00). We suggest that on-site release of nuisance black bears is an appropriate technique to reduce recurrence of nuisance activity while maintaining an acceptable survival rate in GSMNP.

Key words: American black bear, Great Smoky Mountains National Park, nuisance activity, on-site release, translocation, *Ursus americanus*

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Since the establishment of GSMNP in 1934, interactions between black bears and visitors have occurred regularly (Singer and Bratton 1980, Tate and Pelton 1983, Hastings et al. 1987). Prior to 1990, capture and translocation was the primary management option for nuisance bears. However, low success and survival associated with translocated black bears (Stiver 1991), insufficient area to translocate bears within GSMNP (Beeman and Pelton 1976), and a decreased interest by state wildlife agencies to receive translocated bears (E.K. Delozier, National Park Service, Gatlinburg, Tennessee, USA, personal communication, 1997) led park biologists to explore alternative solutions. Since 1990, GSMNP biologists have used capture and on-site release as the primary technique for managing nuisance black bears; this technique involves capturing and immobilizing bears that frequent developed areas, collecting biological data, and releasing them at the capture site. The premise of on-site releases is that capture and subsequent handling by humans provide aversive stimuli that reinforce the bear's natural fear of humans, resulting in avoidance of the developed area where capture occurred.

Little information is available concerning on-site releases as a management technique for nuisance black bears. Studies evaluating on-site releases have documented success in deterring nuisance bears from developed areas in Florida (Brady and Maehr 1982, Wooding 1988), Arkansas (Shull 1994), and GSMNP (Clark 1999). Clark et al. (2002) identified factors that resource managers could consider to improve success of on-site releases. Important variables associated with successful on-site releases in GSMNP included sex, presence of young, type of developed area where capture occurred, time of day that a bear was active in a developed area, and bear population abundance (Clark et al. 2002).

Success in the above studies was mostly based on recurrence of nuisance behavior. Although cessation of nuisance activity is likely of primary interest to managers, information pertaining to survival of bears released on-site is lacking and may influence the ultimate effectiveness

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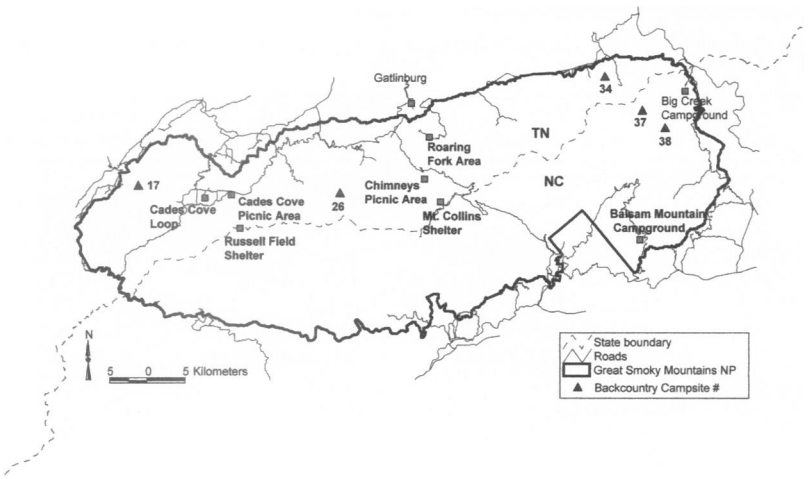

Fig. 1. Locations (squares and triangles) of on-site releases of radiocollared, nuisance American black bears in Great Smoky Mountains National Park, Tennessee and North Carolina, 1997–98.

of the technique. For example, if survival rates of bears released on-site in GSMNP were unacceptably low, biologists may want to reconsider on-site release as their primary management technique for nuisance black bears. Therefore, we estimated short-term survival of nuisance black bears released on-site in GSMNP.

Methods

Data for our study were collected in GSMNP, a 2,080-km^2 area along the Tennessee and North Carolina border (Fig. 1). The area is characterized by steep, mountainous terrain with elevations ranging from 270–2,024 m. GSMNP is partially surrounded by Cherokee National Forest in Tennessee and Nantahala and Pisgah National Forest in North Carolina. Most of the Tennessee portion of GSMNP is bordered by private land, much of which is developed. The Cherokee Indian Reservation borders the southeastern portion of the national park. Although hunting is not permitted in GSMNP, both North Carolina and Tennessee have fall hunting seasons for black bear in counties adjacent to GSMNP.

GSMNP is the most visited national park in the United States with more than 9 million visits per year. Developed areas included 10 frontcountry campgrounds, 9 picnic areas, 99 backcountry campsites, and 16 backcountry shelters. During 1998, overnight stays at backcountry campsites and developed campgrounds numbered 92,522 and 357,623, respectively (Great Smoky Mountains National Park, National Park Service, Gatlinburg, Tennessee, USA, unpublished data). Between 1990 and 1998, 1,414 nuisance bear incidents were reported. Property damage was involved in 516 of these incidents resulting in an estimated cost of $39,069. Additionally, 18 nuisance incidents involved human injuries (E.K. Delozier, unpublished data).

We, along with GSMNP personnel, monitored developed areas in the frontcountry (i.e., picnic areas, roadsides, and campgrounds) and backcountry (i.e., primitive campsites) of GSMNP for nuisance bear activity during May 1997–December 1998. In accordance with GSMNP biologists, we defined nuisance bear activity as any observation of a black bear in a developed area. We monitored frontcountry areas by spotlighting, visual observations, and visitor reports. We primarily relied on visitor reports to monitor backcountry areas. When we detected bear activity in a developed area, we attempted to capture the offending bear promptly after the initial observation or report. We captured bears with aluminum culvert traps, spring-activated Aldrich foot snares (Johnson and Pelton 1980), and by immobilizing free-ranging bears with a carbon dioxide capture pistol. Bears captured in frontcountry areas were transported to GSMNP headquarters for processing when logistically feasible. We baited traps with sardines, bacon, or bakery products. We immobilized bears with a mixture of ketamine hydrochloride (200 mg/ml), xylazine hydrochloride (100 mg/ml), and mepivicaine hydrochloride (20 mg/ml) injected intramuscularly at a dosage of 1 ml/22.5 kg estimated body weight. Each bear was ear-tagged in both ears and tattooed on the upper lip and flank of the groin area with a unique number. We extracted a premolar tooth for aging based on cementum annuli. We fitted each bear with a radiocollar (Telonics MOD-500) equipped with activity and mortality tip-sensors (Telonics, Mesa, Arizona, USA). When handling was completed, bears were given an intravenous injection of yohimbine hydrochloride (1 ml/19.0 kg estimated body weight) as an antagonist for xylazine hydrochloride. All bears were allowed to recover before subsequent release.

We released bears <150 m from their capture location. After release, we used radio telemetry, visitor reports, and spotlighting to monitor nuisance bear activity at the release site. If a bear was observed at its release loca-

Table 1. Fate of radiocollared, nuisance American black bears released on-site in Great Smoky Mountains National Park, 1997–98.

Bear ID	Capture date	Sex	Age	Capture location	Fate	Censor or mortality month
248[a]	20 May 1997	M	2.5	Chimneys Picnic Area	Active	Dec 1997
277	5 Jun 1997	M	2.5	Chimneys Picnic Area	Hunter kill	Oct 1997
1357[b]	12 Jun 1997	M	3.5	Chimneys Picnic Area	Hunter kill	Oct 1997
175[b,c]	3 Jul 1997	F	11.5	Chimneys Picnic Area	Translocated	Oct 1997
283	4 Jul 1997	F	8.5	Campsite 37	Translocated	Aug 1997
288[a]	6 Jul 1997	F	8.5	Chimneys Picnic Area	Active	Dec 1997
291	15 Jul 1997	M	4.5	Chimneys Picnic Area	Active	Dec 1997
144[c]	5 Aug 1997	F	7.5	Chimneys Picnic Area	Translocated	Oct 1997
308	19 May 1998	M	3.5	Campsite 38	Active	Dec 1998
314	24 May 1998	M	4.5	Campsite 26	Active	Dec 1998
316	27 May 1998	M	3.5	Campsite 17	Active	Dec 1998
317	3 Jun 1998	F	3.5	Russell Field Shelter	Active	Dec 1998
318	10 Jun 1998	M	4.5	Mt. Collins Shelter	Active	Dec 1998
236	18 Jun 1998	F	9.5	Chimneys Picnic Area	Active	Dec 1998
319	24 Jun 1998	M	2.5	Big Creek Campground	Active	Dec 1998
325	5 Aug 1998	F	4.5	Cades Cove Loop Road	Active	Dec 1998
321	12 Aug 1998	F	4.5	Campsite 34	Active	Dec 1998

[a]Bears 248 and 288 were observed at their release location following on-site release but did not require additional capture and handling.
[b]Bears 175 and 1357 were captured and released on-site 2 times within the same year prior to translocation.
[c]Female with young.

tion, it was hazed (chased) or captured and released on-site a second time or translocated. Because radiocollars were removed from bears prior to translocation, we did not monitor bears following translocation. We monitored radiocollared bears released on-site via ground and aerial telemetry 1–3 times/2 weeks from May 1997 to December 1998. We recorded release date, first and last date monitored, sex, and fate of all radiocollared bears.

We estimated survival of bears released on-site from May to the onset of the denning season in December using the Kaplan-Meier staggered entry procedure (Pollock et al. 1989). We tested for differences in the survival functions between years using a log-rank test (Pollock et al. 1989) to determine if pooling data for each month across years was appropriate. We only considered bears at risk the year on-site release occurred. Although biologists in GSMNP typically consider an on-site release successful if the offending bear does not require translocation the same year as on-site release (E.K. Delozier, personal communication, 1997), we included bears that were subsequently translocated in the survival analysis if they were at risk >1 month before being translocated. Radiocollared bears that were translocated subsequent to an on-site release were censored (removed from the analysis) starting in the month that translocation occurred. We did not account for variability in survival related to bears being hazed or released on-site twice; thus, we assumed no effect of these management activities on survival. We recorded mortality dates of radiocollared bears from 1997 and 1998 harvest data for North Carolina (North Carolina Wildlife Resources Commission, Raleigh, North Carolina, USA, unpublished data) and Tennessee (Tennessee Wildlife Resources Agency, Nashville, Tennessee, USA, unpublished data).

Results

During 1997–98, we monitored 9 male and 8 female (including 2 females with young) black bears that were released on-site 19 times (10, 6, and 3 times for males, females, and females with young, respectively; Table 1). On-site release areas included picnic areas, frontcountry campgrounds, roadsides, and backcountry campsites (Table 1, Fig. 1). Three of the radiocollared bears (3 females) were translocated and censored at their date of translocation, 2 males were harvested, and 12 bears (7 males, 5 females) were active and censored in December of their respective year of capture (Table 1). Survival functions for 1997 and 1998 were not different ($\chi^2 = 2.57$, 1 df, $P = 0.11$; Clark 1999); thus, we assumed no year effect and pooled data for each month across years. Short-term survival of bears released on-site in GSMNP was 0.88 (95% CI = 0.70–1.00).

Discussion

Our survival analysis of nuisance black bears released on-site in GSMNP was based on a relatively short period following release. Management techniques for nuisance

bears generally strive for immediate results and to prevent recurrence of nuisance bear activity until fall foods become available or the onset of the denning season. Nuisance bear activity in GSMNP typically occurs between May and August (Clark 1999), so we determined survival of nuisance black bears from time of on-site release until December. Because of this short period, no bears were censored during our study due to lost contact or unknown fates. Consequently, we were able to detect any mortality of bears released on-site. Managers in GSMNP considered survival of bears released on-site as acceptable if survival was similar to estimates for non-nuisance bears (E.K. Delozier, personal communication, 1997). Indeed, short-term survival of bears released on-site in GSMNP was comparable to annual survival estimates from a population study of non-nuisance bears captured along backcountry traplines in GSMNP during 1989–2001 (95% CI = 0.71–0.79; F.T. van Manen, unpublished data).

Human-induced mortality, particularly hunting, is the major source of mortality of adult black bears (Rogers 1976). Both mortalities recorded in our study were males (Bears 277 and 1357) and occurred outside the national park as a result of legal hunting in October 1997 (Table 1). A poor mast crop and high bear density in the fall of 1997 contributed to increased movements by bears and a record bear harvest for Tennessee and North Carolina. Thus, survival of bears released on-site, as well as the overall bear population, likely was negatively affected. Furthermore, males in GSMNP have larger home ranges than females (Garshelis and Pelton 1981) and are more likely to occupy areas outside GSMNP, where exposure to various mortality factors, such as legal and illegal hunting, is greater. Indeed, six males in our study (Bears 248, 277, 291, 308, 319, and 1357) had home ranges with portions outside GSMNP, whereas all female home ranges were within the national park (Clark 1999).

Management implications

Wildlife managers have limited options to effectively deal with nuisance problems caused by black bears. Translocations of nuisance bears have had limited success and often result in a marked decrease in survival (Fies et al. 1987, Rogers 1986, Stiver 1991, Comly 1993). Furthermore, translocation of adult males may increase nuisance activity from an influx of sub-adult males from other areas (Tate and Pelton 1983). Euthanasia provides another management alternative but is typically used only as a last resort. The on-site release technique has received increased attention because it may prevent recurrence of nuisance activity without affecting the social structure of the local population. However, the overall effectiveness and value of on-site releases to bear managers may depend on survival of bears following release.

The overall success rate (no translocation) of on-site releases in GSMNP (73% during 1990–98; Clark et al. 2002) and high survival rate of released bears documented in our study indicate the potential effectiveness of the on-site release technique. The high survival of female bears released on-site may be particularly important because of their potential contribution to the population through the production and rearing of young. At least 4 females released on-site during our study were observed with cubs in subsequent years. Therefore, when circumstances are appropriate, on-site releases, particularly of female bears, may provide a better management alternative than translocation or euthanasia.

Success of on-site releases in GSMNP likely was enhanced by National Park Service efforts to minimize availability of human foods in developed areas through bear-proof garbage facilities and frequent sanitizing of developed areas. Thus, on-site releases may not be as successful and survival may not be as high in areas where human food sources are easily accessible. We suggest that on-site release of nuisance black bears is an appropriate technique to reduce recurrence of nuisance activity while maintaining an acceptable survival rate in GSMNP and may be useful in mitigating nuisance bear problems in other bear management programs.

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