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Abstract: Complaints associated with nuisance activity by Louisiana black bears *(Ursus americanus luteolus)* in south Louisiana have steadily increased since 2000, demanding intervention by state and federal agencies. As a federally threatened species, Louisiana black bears that are a nuisance require nonlethal management, referred to as aversive conditioning. We used rubber buckshot and dogs to test the effectiveness of management techniques used by the state of Louisiana to deter nuisance bear activity. We captured 11 bears in residential and industrial areas where nuisance bear activity was reported. We fitted bears with radio-transmitting collars and released them within 2 km of the capture site. We conditioned 5 bears using only rubber buckshot and 6 bears with rubber buckshot and dogs. Bears were monitored using telemetry to estimate movements and space use. All bears remained within 2 km of capture sites 2 weeks following release. Ten bears (91%) returned to nuisance behavior within 5 months, regardless of treatment. Mean distance from capture sites did not differ between treatments. Our results suggest that aversive conditioning techniques used in Louisiana to deter bears from nuisance activity have limited short-term effectiveness, independent of practices addressing food source.

Key words: Atchafalaya Basin, aversive conditioning, black bear, human–bear conflicts, human–wildlife conflicts, Louisiana, nuisance, *Ursus americanus luteolus*

In coastal Louisiana, the threatened Louisiana black bear (*Ursus americanus luteolus*) resides in highly fragmented areas, with a relatively small number (< 100) of individuals living in isolated patches of habitat separated by obstacles, such as high-speed roadways and sprawling urban and suburban development, that consequently place them close to humans (Cotton 2008). According to the Louisiana Department of Wildlife and Fisheries (LDWF), reports and complaints associated with nuisance activity by bears have increased steadily since 2000 (M. Davidson, LDWF, personal communication).

As a threatened subspecies listed under provisions of the Endangered Species Act (ESA) in 1992, Louisiana black bears are federally protected and require nonlethal management when nuisance situations arise. In response to increased bear–human conflicts, LDWF and the U.S. Department of Agriculture (USDA) Wildlife Services implemented a commonly-used technique referred to as aversive conditioning. Aversive conditioning is a method designed to provide the offending animal with a negative experience using various deterrent measures, such as rubber buckshot, loud noise, and dogs, in hopes that the offender resigns from nuisance behavior (Conover 2002). Various methods of aversive conditioning, such as lithium chloride, loud noise, pepper spray, rubber buckshot, and dogs have been used on nuisance black bears by state and federal agencies across North America, but limited research has been conducted testing effectiveness of these methods in deterring nuisance bear behavior (Colvin 1976, Hunt 1984, Gillin et al. 1994, Ternent and Garshelis 1999, Beckmann et al. 2004). Louisiana, much like other states, uses aversive conditioning techniques with limited knowledge of the effectiveness on bear behavior following release and conditioning. The intent of on-site release coupled with aversive conditioning of bears

Black bears seek food in a garbage bin.

is to reduce human–bear conflicts without displacing bears completely from their home range or the immediate area where conflicts occur (Clark et al. 2002). Presumably, increasing movements of bears away from sites where they caused problems in the past, without permanently displacing them, is a positive step towards reducing these conflicts.

Our objective was to compare the effectiveness of both the 2 aversive-conditioning methods used in Louisiana by examining space use and movements of bears following their release and conditioning. Ultimately, we sought to provide information on bear behavior following conditioning, thereby indicating the effectiveness of conditioning techniques used to deter nuisance activity by black bears in south Louisiana.

Study area

We conducted research in the coastal region of the Atchafalaya River Basin of south Louisiana in St. Mary, Iberia, and Vermilion parishes, which encompassed 6,112 km^2 of freshwater marshes and bayous, lowland forests, farmlands, industrial, recreational (private and public), and residential areas. The human population was estimated at 180,963 (U.S. Census Bureau 2005), and the estimated abundance of black bears was 77 $\pm$9 (Triant et al. 2004).

The Bayou Teche National Wildlife Refuge (NWR) located in St. Mary Parish was composed of 37 km^2 of designated black bear habitat. The refuge, like much of the study area, was fragmented by improved and unimproved roadways that presented bears with obstacles when traversing their home ranges. Roadways, such as U.S. Highway 90, are major contributors to black bear mortality due to bear–vehicle collisions in the study area (Pace et al. 2000). Habitat degradation was evident throughout the study area where the emergence of golf courses, parks, subdivisions, and shopping centers has rapidly encroached into once historic bear habitat, escalating bear–human interaction due to the subsequent loss of natural food items and the increasing presence of refuse generated by humans (Rogers et al. 1976, Nyland 1995). Man-made channels and canals, in addition to pipelines and levees created by oil and gas companies and the U.S. Army Corps of Engineers, also have affected bear habitat throughout the region. Industrial areas such as oil, gas, and salt plants are prominent components on Louisiana's coastal landscape. These industries contribute greatly to the region's economy, supplying jobs to thousands of local and transient contractors. Consequently, considerable refuse is generated, causing bears to become highly habituated to human contact.

Methods

Black bear capture and handling

Using a combination of culvert traps (Figure 1) and modified Aldrich snares (Johnson and Pelton 1980), we captured black bears from April 2005 to February 2006 in areas of St. Mary, Iberia, and Vermilion parishes that reported nuisance bear activity. We immobilized bears chemically with an intramuscular injection of Telazol® delivered by blow dart or CO_2 gun. We fitted adult and sub-adult bears (males > 70 kg and females > 45 kg) with mortality-sensitive radio collars (Advanced Telemetry Systems, Isanti, Minn.) containing breakaway leather spacers. We marked the bears with lip tattoos, pit-tag microchips (injected under the skin between shoulder blades), and ear tags. We assessed tooth wear, body size, and physical condition to estimate age. We conducted our research under Louisiana State University Agricultural Center Institutional Animal Care and Use Committee Protocol #A-03-04.

Figure 1. Culvert traps (pictured) allowed bears to recover from immobilizing injections after capture and tagging.

Aversive conditioning and telemetry

Following data collection and collaring, we placed bears in culvert traps (Figure 1) where they were allowed to fully recover (for up to 24 hours) at the capture site. Once they recovered, we assigned each bear to 1 of 2 treatments. Bears were assigned treatments systematically to ensure an equal number of bears in each treatment. Bears assigned to the first treatment were conditioned upon exit from the trap with rubber buckshot (Less Lethal Wildlife Control Lightfield Ammunition) fired from a 12-gauge shotgun, loud voices, and excessive noise (Figures 2 and 3). Bears assigned to the second treatment were conditioned using these same methods, and in addition, they were chased by dogs (black-mouthed curs) until the bears were known to have left the immediate area. We attempted to recapture bears exhibiting reoccurring nuisance behavior; successfully recaptured bears were reconditioned using the second treatment, regardless of the initial treatment used. Reoccurring nuisance bears that could not be recaptured were conditioned opportunistically using the first treatment when observed displaying nuisance behavior. Once additional conditioning occurred, these individuals were excluded from evaluations of space use and movements (i.e., data used for comparing movements between treatments ceased, see below). We measured treatment effectiveness in time (number of days) bears did not display nuisance activity, in addition to the distance bears moved away from capture sites following conditioning.

We monitored the bears intensively with radiotelemetry following their release to estimate their movements and use of space. We located each bear once per hour during the first 4 hours after their release, then once every 4 hours for 24 hours following their release. Subsequently, monitoring intensity decreased, unless the individual exhibited reoccurring nuisance behavior. Our monitoring protocol (>24 hours following release) included 4 locations per bear per day recorded during days 2–7; 2 locations per bear per day during days 8–14; 3–5 locations per bear per week during days 15–90; and occasionally (several times monthly), thereafter. All locations were distributed throughout the diel period and separated by a minimum of 1 hour during days 2–7 and 4 hours thereafter. We estimated bear locations from readings taken at temporary and fixed stations using a global positioning system (GPS) in Universal Transverse Mercator (UTM) coordinates. We triangulated locations using field maps to ensure accuracy during data collection, and then obtained more precise locations using radiotelemetry-based software (Locate II and LOAS 3.2).

Estimating space use and movements

We estimated distance between consecutive locations to evaluate bear movements relative to treatment and to provide insight into how bears traversed their home range following release. To evaluate space use, we estimated 95% and 50% contours (core area of use) using fixed kernel estimators (Seaman and Powell 1996, Powell et al. 1997) for each bear in the home range, animal movement, and spatial analyst extensions in ArcMap 9.1 (Environmental Systems Research Institute, Redlands, Calif.). To estimate mean distance bears moved from capture sites during the first 24 hours and 2 weeks following release,

Figure 2. A bear is released from a culvert trap after being tagged and radio-collared.

Figure 3. Shotguns were used to deliver rubber buckshot to a nuisance black bear upon its release from capture as part of an aversive conditioning treatment.

we spatially joined telemetry locations of each bear for each time period to respective capture sites using ArcMap 9.1.

We investigated the differences between treatments based on mean distances all bears moved from capture sites during both the first 24 hours and 2 weeks following release and until bears were observed displaying reoccurring nuisance behavior. We conducted all statistical analyses using SAS 9.1 (SAS Institute, Cary, N.C.). We used unpaired *t*-tests to evaluate differences in the bears' use of space between treatments. Because of small sample sizes, we used least squared estimates with 95% confidence intervals about the mean (95% CI).

Results

Space use

We collected data on 11 nuisance bears (9 male and 2 female) in 790 locations from April 2005 to July 2006 to estimate space use and distances moved from capture sites during both the first 24 hours and 2 weeks following release. Space use (95% contour) was similar (t_9 = -0.89, P = 0.40) between bears conditioned with dogs (n = 6; $\bar{x}$ = 12.6 km^2, SE = 2.4) and without dogs (n = 5; $\bar{x}$ = 8 km^2, SE = 1.9). Similarly, core area use was similar (t_9 = -0.62, P = 0.55) for bears conditioned with dogs ($\bar{x}$ = 1.3 km^2, SE = 0.4) and without dogs ($\bar{x}$ = 1.9 km^2, SE = 1.0).

Bear movements following treatment and release

In all cases, bears conditioned with dogs moved greater distances following release than did those conditioned without dogs, suggesting that bears may have been influenced by the added use of dogs. During the 24 hours following release, bears conditioned without dogs moved an average of 1,197 m (95% CI = -14.8–2,409 m) from the capture sites, whereas those conditioned with dogs moved 1,855 m (95% CI = 8,96.3–2,813 m) from capture sites. On average, bears remained within 2 km^2 of respective capture sites 2 weeks following conditioning and release. Bears conditioned without dogs moved an average of 1,172 m (95% CI = 3–2,340 m) from the capture sites, and those conditioned with dogs moved 2,091 m (95% CI = 1,019–3,169 m) from the capture sites 2 weeks following release (Figure 4). A similar trend was observed for bears (n = 10) displaying reoccurring nuisance behavior following release; bears conditioned without dogs moved an average of 1,312 m (95% CI = -470.8–3,094 m) from the capture sites, whereas those conditioned with dogs moved 3,463 m (95% CI = -7.3–6,933 m) from capture sites.

Ten bears (91%) returned to nuisance behavior within 5 months of being captured and treated with aversive conditioning, regardless of treatment used. Bears conditioned without dogs refrained from nuisance activity an average of 48 days (SE = 22), whereas those conditioned with dogs refrained slightly longer ($\bar{x}$ = 58 days, SE = 29). Only 1 bear returned to its capture site, the remaining 9 bears became a reoccurring nuisance elsewhere. Mean distance from the original capture site to the site of confirmed reoccurring nuisance behavior was documented at 3,152 m (range = 38–7,122 m). Bears (n = 6) that were reconditioned with rubber buckshot and loud noise while observed displaying reoccurring nuisance behavior moved an average of 949 m (range = 30–4,410 m) from new sites 24 hours following reconditioning. Only 1 of the 10 bears exhibiting reoccurring nuisance behavior was recaptured and reconditioned with dogs; he moved 4,732 m from the recapture site 24 hours following reconditioning and release. This distance was greater than the distance he moved when he was originally captured

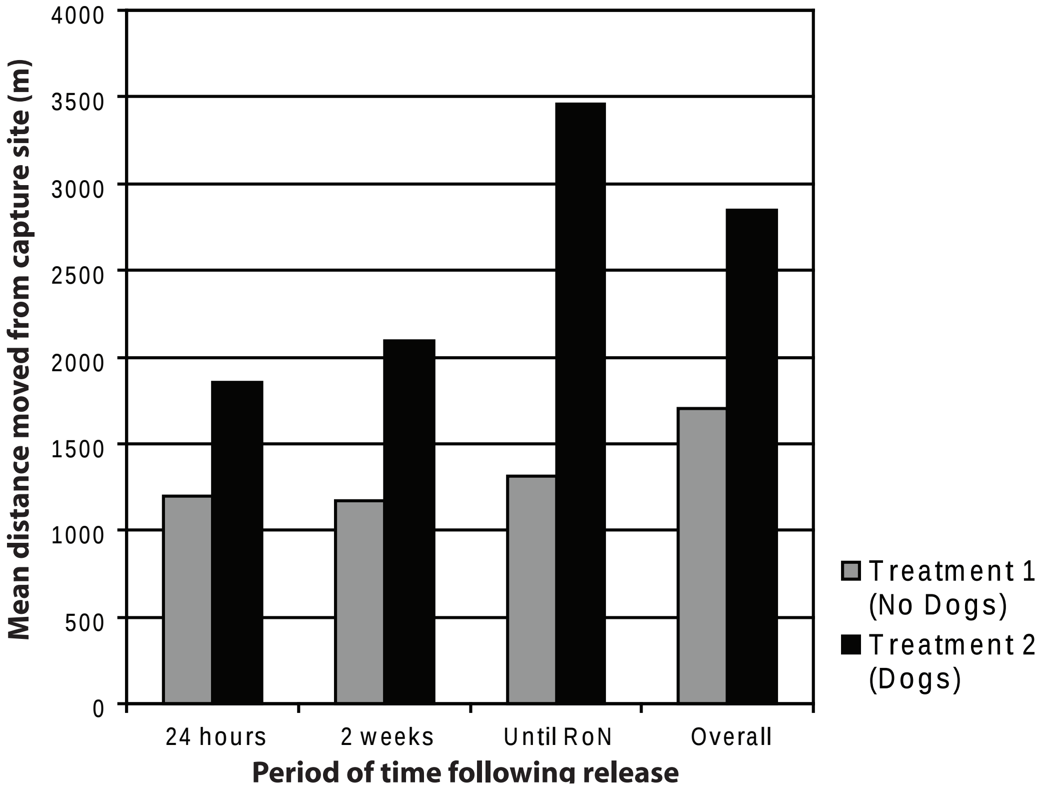

FIGURE 4. Mean distance (m) nuisance bears moved from capture sites after 2 aversive-conditioning treatments with no dogs and with dogs during 24 hours and 2 weeks following treatment in southern Louisiana, 2005–2006. Bears were monitored until they were observed displaying reoccurring nuisance behavior (RoN).

and exposed to treatment without dogs. Bears exhibiting habitual nuisance behavior (≥3 reoccurring nuisance events) did so ≤48 days after reconditioning with a mean distance of 148 m (range = 30–519 m) between consecutive events. One bear was observed continuing nuisance behavior twice in the same day at sites within 450 m of each other.

Discussion

Human–bear conflicts pose significant concern in urban–wildland interfaced communities throughout North America (Beckmann 2008, Brown and Conover 2008, Lemelin 2008, Thiemann et al. 2008, Ziegltrum 2008) and the world (Worthy and Foggin 2008). Reports involving nuisance black bears have increased in magnitude and frequency, with an increase of more than 1,500 cases reported in the last decade throughout eastern portions of the United States (Spiker, unpublished data). Increasing human encroachment into once historic black bear habitat has significantly contributed to the escalation of human–bear conflicts due to the loss of natural food items and the increasing presence of refuse generated by humans (Rogers et al. 1976, Conover 2008). The Coastal Atchafalaya River Basin (CARB) region, a prevalent source of human–bear conflict reports, has experienced an increase of >2,824 people since 2000 (U.S. Census Bureau 2005). However, black bear population estimates from previous mark-recapture research reported an abundance of 77 ± 9 bears in the CARB (Triant et al. 2004), and concern exists regarding the future viability of this population (Pace et al. 2000).

Many states have addressed human–bear conflicts by implementing nonlethal deterrent measures in addition to adjusting hunting season regulations (i.e., length of season, baiting, and bag limits). Louisiana is 1 of 8 states in the eastern United States that currently does not allow harvest of black bears; the season was closed in 1988, and the subspecies was consequently listed as federally threatened in

1992. Since 2000, Louisiana has experienced a notable increase in human–bear conflicts. The Louisiana Department of Wildlife and Fisheries (LDWF) has received an annual average of 200 nuisance complaints, requiring increased attention from state and federal agencies. To date, wildlife management agencies have been limited to nonlethal management practices, such as aversive conditioning, to contend with rising nuisance black bear activity.

Our findings suggest that the use of dogs to condition bears results in increased movement of bears away from sites where nuisance activity occurred, compared to conditioning bears without dogs. However, this apparent positive outcome is tempered by the fact that nuisance bears in our study returned to nuisance behavior regardless of the treatment used. Likewise, Beckmann et al. (2004) reported that 92% (n = 57) of bears returned to nuisance behavior, with 70% (n = 44) returning within 40 days following release, regardless of treatment used. Additionally, they observed behavioral trends similar to those we observed in our study. Bears treated with dogs remained farther away for slightly longer periods of time than those treated with other deterrent methods alone. In our study, this trend also was demonstrated in mean distance bears moved following conditioning for all periods examined between treatments; bears treated with dogs moved greater distances from capture sites and refrained from nuisance behavior slightly longer than those treated without dogs.

Sample size, the most documented limiting factor in studies monitoring behavior of large carnivores, proved also to be an important but unavoidable limitation in our study. Although nuisance bears captured during our study represented approximately 15% of the estimated subpopulation (Triant et al. 2004), a larger sample size would certainly be desirable. Difficulty in attaining a larger sample size was partially a function of problems associated with trapping and nuisance reporting. Based on discussions with homeowners, we speculate that >50% of nuisance bear activity in residential areas was not reported due in part to confusion about whether bears were the source of the problem. Many residents who were consulted during our study did not actually see bears exhibiting nuisance activity. Furthermore, we noted that in cases where nuisance activity was repeatedly reported, it typically resulted from activity of a bear already captured and treated during our study. Therefore, many of the reports we received and responded to were attributable to a small sample of bears, despite the fact that the sample represented a substantial portion of the estimated population.

Although a toll-free hotline for reporting nuisance bear activity was provided by LDWF, residents still had limited knowledge of how to report nuisance bear activity. We noted that citizens were sometimes discouraged by not knowing whom to contact and were dissatisfied with responses by local law enforcement and state and federal agencies responsible for nuisance bear management. We recognize that our study did not directly quantify social issues relative to nuisance bear activity. Nevertheless, the lack of on-site personnel dedicated to handling concerns about nuisance bears in affected areas and a generally slow response (e.g., >5 days) to nuisance reports likely contributed to concerns voiced to us by citizens. Reports of nuisance bear activity are currently routed from administrative personnel (via a toll-free hotline) to personnel at LDWF in Baton Rouge (a 1-hour-and-45-minute drive from our study site). Upon receipt of complaints, the persons reporting nuisance bear activity are contacted by LDWF for information about the incident. Only those complaints that are attributed to reoccurring nuisance activity result in on-site management. An effective solution, ensuring prompt on-site response to nuisance bear complaints, would involve dedicating trained personnel to areas reporting consistent nuisance bear activity. Although this practice may be an effective means in decreasing human–bear conflicts, it would require additional allocation of funds and resources to implement in affected areas. We suggest these factors be considered when assessing future management practices for nuisance black bears in Louisiana.

Our findings, similar to those of previous studies, suggest that deterrent methods currently adopted by many state and federal agencies have limited short-term effectiveness (Beckmann et al. 2004), particularly when used independently of managing access to food sources that result in bears becoming a nuisance. A more interactive approach should be considered in the management of human–bear conflicts, placing greater emphasis on public education to prevent nuisance bear behavior. Nuisance bear activity in our study was typically centered on bears using garbage in residential and industrial areas. Hence, measures addressing the availability of food from humans should be pursued aggressively (Madison 2008). Such measure include implementing governing ordinances with stiff penalties against the intentional feeding of black bears and using bear-proof trash containers in areas witnessing nuisance bear activity. LDWF, in cooperation with the U.S. Fish and Wildlife Service, passed a no-feeding ordinance in 2002 and subsequently provided residents in affected areas of St. Mary Parish with bear-proof trash containers. LDWF has since reported a reduction in nuisance bear complaints where containers were distributed (M. Davidson, LDWF, personal communication), suggesting that this approach may have been a successful factor in reducing human–bear conflicts.

Tavss (2005) suggested that human–bear conflicts can be addressed successfully by using nonviolent programs that include public education regarding the propensity of bears to eat garbage (placing great emphasis on never feeding bears, intentionally or unintentionally), bear-proofing garbage containers, and enforcing ordinances regarding human refuse. National parks in the United States (e.g., Yellowstone, Yosemite, and Great Smoky Mountains) and communities bordering black bear habitat (e.g., Juneau, Alaska; the Lake Tahoe Basin, Nevada; and Elliot Lake, Ontario, Canada) that use these programs have reported fewer conflicts involving nuisance black bears. In all instances, the removal of food sources has been successful in substantially reducing by 40 to 80% the number of human–bear conflicts reported (Tavss 2005).

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