Title
Response of Mountain Lions to Hazing: Does Exposure to Dogs Result in Displacement?

Journal
Proceedings of the Vertebrate Pest Conference, 31(31)

ISSN
0507-6773

Authors
Winter, Sierra Y.
Van Vuren, Dirk H.
Vickers, T. Winston
et al.

Publication Date
2024

Response of Mountain Lions to Hazing: Does Exposure to Dogs Result in Displacement?

Sierra Y. Winter and **Dirk H. Van Vuren**
Department of Wildlife, Fish, and Conservation, University of California, Davis, California
T. Winston Vickers
Wildlife Health Center, University of California, Davis, California
Justin A. Dellinger
Large Carnivore Section, Wyoming Game and Fish Department, Lander, Wyoming

ABSTRACT: Hazing has been advocated as a non-lethal solution to human-predator conflicts, but the efficacy of hazing is not well documented, especially for mountain lions. We conducted a study of mountain lions throughout the state of California during 2001-2021 to determine if hazing with dogs has potential for deterring mountain lions from returning to sites of conflict. We used data on 76 mountain lions captured and equipped with radio collars; 34 lions were exposed to barking dogs during capture, then further exposed to barking dogs upon release (dog-exposed), and 42 lions were captured and released without exposure to dogs (control). We found that distance from the capture site was similar for dog-exposed and control mountain lions through 45 days following release, except for a slightly greater distance for dog-exposed lion shortly after release. Almost all mountain lions (94-98%) returned to within 6 km of the capture site during the 45 days following release, and most (77-88%) returned to within 1 km, with no significant difference between dog-exposed and control mountain lions. Therefore, aside from a modest short-term effect, we did not find evidence that hazing with dogs is an effective method for displacing mountain lions from a conflict location.

KEY WORDS: aversive conditioning, dogs, GPS tracking, hazing, mountain lion, non-lethal management, *Puma concolor*

Proceedings, 31st Vertebrate Pest Conference (R. M. Timm and D. M. Woods, Eds.)
Paper No. 14. Published September 30, 2024. 7 pp.

INTRODUCTION

Conflicts between humans and predators are an important wildlife issue today and arise primarily from depredation on livestock and threats to human safety (van Eeden et al. 2018, Petracca et al. 2019). Depredation incidents can have substantial financial repercussions, costing in the millions of dollars annually (U. S. Department of Agriculture 2010, U. S. Department of Agriculture 2011). Predators can also attack humans; each year an average of 539 people are injured and 0.8 people killed by mammalian predators in the United States (Conover 2019). For example, mountain lions (*Puma concolor*) attacked 74 people and killed 11 people in 10 states in the western United States between 1924 and 2018 (Wang et al. 2019). These attacks may be a result of increased human activity and reduction and fragmentation of suitable mountain lion habitat (Torres et al. 1996).

Lethal removal of offending animals has historically been the primary way of managing depredation (Pierce and Bleich 2003). However, the public is increasingly opposed to lethal predator management (Swan et al. 2017, Sampson and Van Patter 2020). Furthermore, lethal control can impact the viability of local predator populations (Cunningham et al. 2001). For example, in 2019, 73 mountain lions in California were killed under depredation permits (California Department of Fish and Wildlife 2020), and lethal control of mountain lions due to depredation incidents can be the primary source of mortality in non-hunted mountain lion populations (Vickers et al. 2015, Dellinger and Torres 2020, Nisi et al. 2022). Areas with high rates of lethal control may even become "mortality sinks" for some mountain lion populations (Cunningham et al. 2001).

Non-lethal approaches are increasingly used as an alternative to lethal control (Shivik 2004). For example, depredation of livestock may be reduced by modified husbandry practices such as housing animals at night, keeping livestock away from terrain used for hunting by predators, and employing livestock protection animals, including dogs, llamas, and donkeys, (Cunningham et al. 1999, Mazzolli et al. 2002, Ogada et al. 2003). Non-lethal depredation control methods also include transporting "problem" predators to locations away from areas of conflict. However, this method is controversial due to the potentially low survival of translocated predators (Ruth et al. 1998), or the possibility that they will return.

Hazing, which involves harassing wildlife, has been increasingly advocated as a non-lethal solution to human-predator conflicts (Brady 2016, Bonnell and Breck 2017). Hazing is a form of aversive conditioning that uses negative stimuli to induce the animal to move away from the location of conflict (Lackey et al. 2018, Young et al. 2019, Ogden 2021). Efforts to haze predators using loud noises, non-lethal projectiles, or chasing by humans as negative stimuli have produced inconsistent results. Some studies showed promising outcomes (Schirokauer and Boyd 1998, Gillen et al. 1994, Petracca et al. 2019), although the effect often was short-term (Leigh and Chamberlain 2008, Mazur 2010, Comeau 2013), whereas others showed little change in behavior or a mixed response (Beckmann et al. 2004, Rauer et al. 2003, Breck et al. 2017).

Chasing by dogs also has been explored as a negative stimulus to haze predators, especially bears (*Ursus* spp.). However, yet again, results are inconsistent. Some studies reported a substantial change in bear behavior (Honeyman 2008, Comeau 2013, Klip 2018), while others did not (Beckmann et al. 2004, Leigh and Chamberlain 2008).

Mountain lions often prey upon large mammals, including domestic livestock (Pierce and Bleich 2003). In many cases when humans are attacked, the mountain lions treat humans as prey (Pierce and Bleich 2003; Wang et al. 2019). A decrease in suitable habitat for mountain lions due to urbanization and cultivated agriculture creates more potential for human-mountain lion interactions, especially in rangeland agriculture (Beier 1991, Alldredge et al. 2019), and depredation of livestock and issues of human safety will likely increase as humans encroach further into mountain lion habitats (Pierce and Bleich 2003). With increasing public resistance to lethal control of predators (Swan et al. 2017, Sampson and Van Patter 2020), non-lethal alternatives are needed. Hazing with dogs has shown potential for mitigating conflicts involving bears (VerCauteren et al. 2013, Lackey et al. 2018), and this approach has been attempted for mountain lions (McBride et al. 2005); however, the results, although promising, were constrained by a limited sample size.

Our objective for this study was to determine if hazing mountain lions with dogs has potential for reducing human-mountain lion conflicts by deterring mountain lions from returning to sites of conflict. We hypothesized that if hazing with dogs is effective, mountain lions exposed to barking dogs would be displaced a greater distance and would be less likely to return than mountain lions that had not been exposed to dogs.

METHODS

The appropriate design for a study such as ours would be to haze mountain lions with dogs at the location of conflict, then compare their responses to those of other lions that were identified at the location of conflict but not hazed. Such a design is logistically challenging, so instead we capitalized on the hazing effect of dogs when used to tree mountain lions for capture, and we included an additional hazing treatment of restrained, barking dogs (McBride et al. 2005) when the lion was released. We obtained radiolocation data on mountain lions from multiple telemetry studies conducted in 11 counties in northern, central, and southern California across different habitats and seasons over the span of 20 years (2001-2021. In all of the included studies, mountain lions were captured, processed, and released using either of 2 methods, 1 that involved dogs (dog-exposed) and 1 that did not (control). Mountain lions that were dog-exposed were captured by being chased and treed by trained dogs. The dogs were mostly bluetick coonhounds working in teams of 4-8. After being anesthetized and processed, the mountain lion was barked at, but not chased, by restrained dogs again after it returned to consciousness and was released. The control mountain lions experienced no exposure to dogs; they were caught in box traps baited with deer meat, anesthetized and processed in the same way as dog-exposed mountain lions, then released. For each captured mountain lion, sex was determined, identifying tags or tattoos were recorded, and age class (subadult or adult) was estimated based on gum recession, tooth wear, and body size (Ashman et al. 1983, Laundre et al. 2000). All mountain lions were fitted with a GPS radio collar and were released at their points of capture. A variety of radio collar types was used, depending on the time period. Radio collars were programmed to record GPS locations at least once per day.

To compare post-release movements of dog-exposed and control mountain lions, we calculated the distance of each mountain lion from its capture site each day through day 10, then every 5 days through day 45 following release; the first 10 days represented the short-term response, and days 15-45 represented the longer-term response. We chose a duration of 45 days because radio collar loss or malfunction reduced our sample size after that time. The number of GPS locations recorded per day varied greatly, both among mountain lions and among days for an individual mountain lion. GPS locations were rarified to a fix rate of 1 location per mountain lion per day using a random selection process. Mountain lions that lacked a GPS location for a given day were excluded from calculations for that day. Mountain lions with more than 2 days of missing location data were excluded from analysis.

To calculate the likelihood of return to the capture site, we considered a mountain lion to have returned if it remained or came back to within either of 2 distances, 1 km or 6 km, from their capture site at any time during days 3 through 45 following release. The 1-km distance criterion approximated the radius (0.7 km) of the average size of a ranch or farm in California (141 ha; U. S. Department of Agriculture 2017), assuming a circular shape, and represents the likelihood of return to a location of conflict. The 6-km distance approximated the average straight-line distance moved per day by a mountain lion in California (6.4 km; Beier et al. 1995) and reflected movement ecology of mountain lions. A 2-day delay was allowed for mountain lions to exit the vicinity of their capture site and resume normal activities; given a 6.4-km daily movement rate (Beier et al. 1995), 2 days would be required for a mountain lion to exceed the greater of our 2 distance criteria (6 km). We compared proportions of dog-exposed and control mountain lions that returned using a chi-square test of independence.

Predator response to hazing might be influenced by age, sex, and prior exposure to humans (Mazur 2010, Petracca et al. 2019, Young et al. 2019), in addition to hazing treatment. We used Generalized Linear Models (GLM) with a Gaussian distribution to determine the association of these factors with the response of mountain lions to exposure to dogs. We performed 2 analyses, 1 for each of the 6-km and 1-km distance criteria. For each analysis, the response variable was the frequency of return, calculated as the number of days from day 3 through day 45 that a mountain lion was within either 1 km or 6 km of its capture site. Sex, age class, and treatment type (dog-exposed or control) were obtained from capture records. Prior exposure to humans was approximated using distance from the capture site to nearest urbanization, which was calculated using the measure feature on ArcGIS after plotting capture locations on urbanization layers (ESRI 2020). The continuous independent variables were centered and scaled. Generalized linear models using all possible combinations of variables were compared using Akaike Information Criteria (AIC). We included all co-variates because available information on potential effects of sex, age, and prior exposure to humans was too sparse to allow generation of a priori expectations. AICc was used instead of AIC to allow for correction for the low ratio of the sample size versus the number of parameters. The model with the lowest AICc was the top model. All models with a ΔAICc ≤2 when compared with the top model were considered to have the same explanatory power. The AICc of the different models was calculated in the package AICcmodavg in R-Studio version 1.3.1093 (R-Studio 2020). The variable coefficients and confidence intervals across the top models were plotted next to each other. The independent variable coefficient estimates, confidence intervals, and Cohen's *d* were then reported using the highest ranked model that included that variable for the relevant distance criterion. Cohen's *d* is a standardized effect size which represents biological magnitude, where *d* = 0.2-0.5 is a small effect size, 0.5-0.8 is a medium effect size, and 0.8 or greater is a large effect size. The larger the effect size, the greater practical significance the difference between the groups has. The coefficients and confidence intervals of statistically significant continuous independent variables were then individually plotted against the dependent variable, using a centered and scaled x-axis since the coefficient estimates were generated using centered and scaled independent variable distributions. Variable coefficients were not statistically significant if they had a high p-value ($P > 0.05$) or a 95% confidence interval that encompassed zero.

RESULTS

Our study totaled 76 mountain lions, 34 that were dog-exposed (12 males, 22 females) and 42 that were not (23 males, 19 females). Mean distance from the capture site over time showed a similar pattern for both dog-exposed and control mountain lions, with an increase in distance until about day 5, when mean distances stabilized at 7-10 km thereafter through day 45 (Figure 1). A possible exception was during days 2-4 after release, when mean distance moved by dog-exposed mountain lions was 10-22% greater than that for control mountain lions. However, confidence intervals overlapped extensively, suggesting the difference was not statistically significant.

For the 1-km radius designation, the proportion of dog-exposed mountain lions that returned to the capture site (76.5%) did not differ ($X^2 = 1.79$, $P = 0.18$) from the proportion of control mountain lions that returned (88.1%). Similarly, for the 6-km radius designation, the proportion of dog-exposed mountain lions that returned (94.1%) did not differ ($X^2 = 0.61$, $P = 0.44$) from the proportion of control mountain lions that returned (97.6%).

The GLM analysis yielded 2 models for the 6-km return distance and 3 models for the 1-km return distance that had a ΔAICc ≤2 from the lowest AICc value, indicating they have explanatory powers that are statistically the same as the highest ranked model for each distance. For the 6-km return distance, the top-ranked model indicated that the number of days returned was influenced by sex and distance from urbanization. The next-ranked model (ΔAICc = 0.89) indicated that the number of days returned was influenced by sex, distance from urbanization, and age class. However, age class was not a statistically significant covariate (4.52, 95% CI = -3.13 – 12.18, $P = 0.25$, Cohen's $d = -1.92$; Figure 2). Using the highest-ranked model, both the sex being male and distance to urbanization (Figure 3) had a negative relationship with the number of days returned (Sex: -9.25, 95% CI = -14.59 – -3.91, $P = 0.001$, Cohen's $d = -1.29$; Distance from urbanization: -3.83, 95% CI = -6.51 – -1.15, $P = 0.006$, Cohen's $d = -1.37$; Figure 3).

For the 1-km return distance, the top-ranked model indicated that the number of days returned was influenced by sex and distance from urbanization. The second-best model (ΔAICc = 0.83) indicated that the number of days returned was influenced by sex, distance from urbanization, and treatment type (dog-exposed versus control).

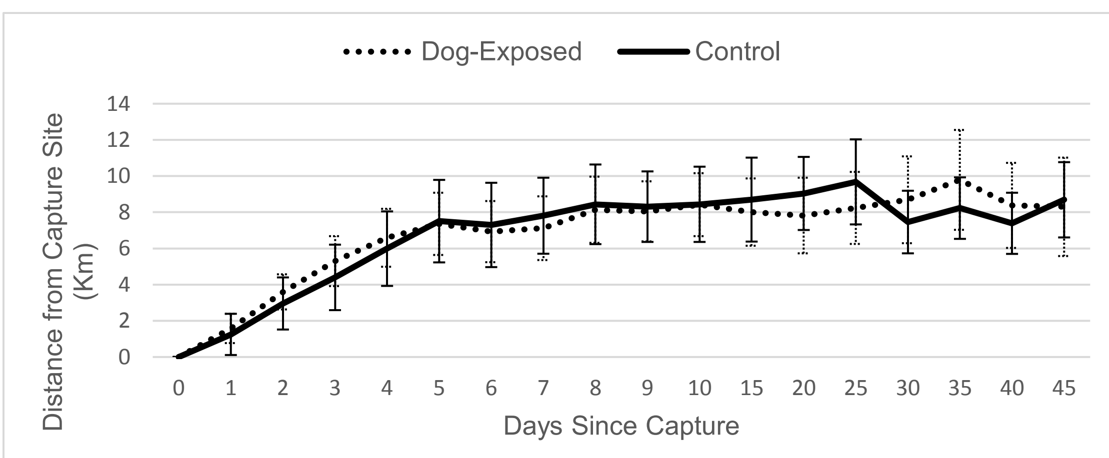

Figure 1. Mean distance from the capture site for dog-exposed and control mountain lions (*Puma concolor*) in California, from 2001-2021, at 1-day intervals up to day 10, and at 5-day intervals thereafter; vertical bars are 95% confidence intervals.

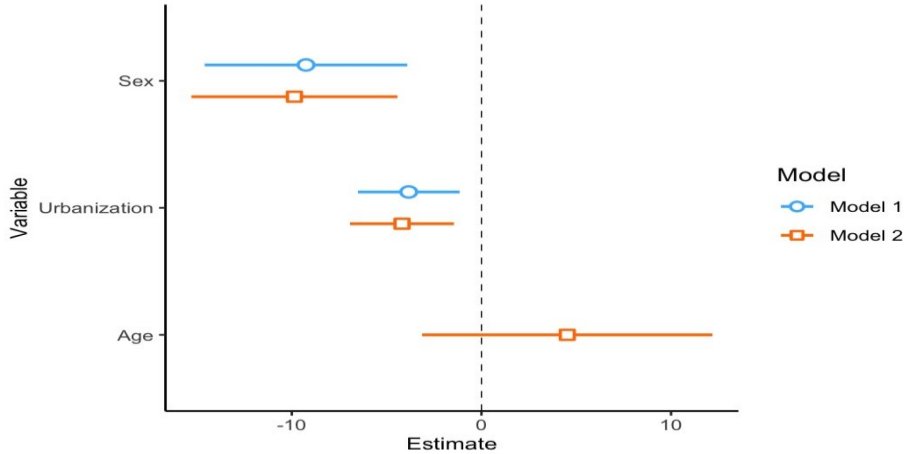

Figure 2. Coefficient estimates based on the top models according to AICc and 95% confidence intervals for the 2 best models for explaining the number of days returned by mountain lions (*Puma concolor*) in California, from 2001-2021, to within a 6-km distance of their capture sites; urbanization refers to the variable of distance from urbanization and age refers to the variable of age class.

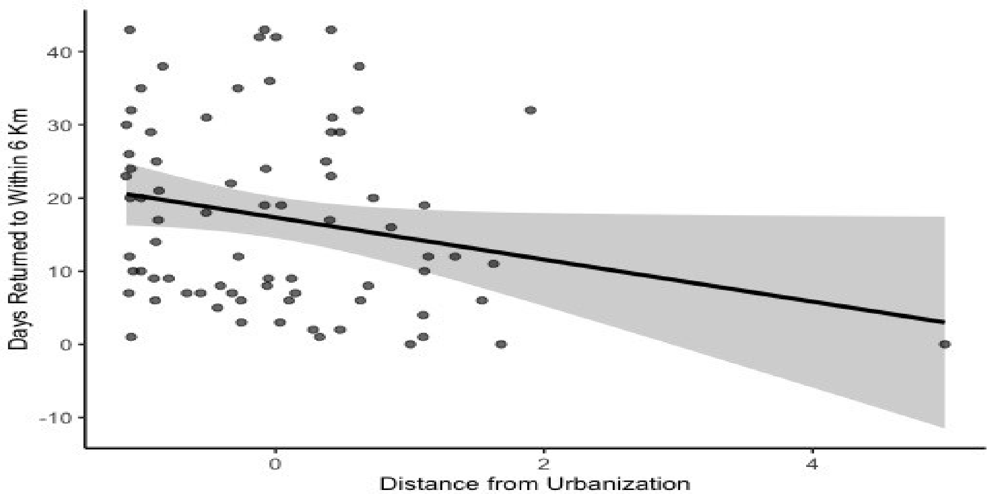

Figure 3. Relation between distance from urbanization and number of days that mountain lions (*Puma concolor*) in California, from 2001-2021, have returned to within a 6-km distance of their capture sites, with shaded areas representing 95% confidence intervals.

However, the variable of treatment type was not statistically significant, though it did indicate that dog-exposed animals took longer to return (-1.71, 95% CI = -4.55 – 1.12, *P* = 0.24, Cohen's *d* = -1.29; Figure 4). The third-ranked model (ΔAICc=1.91) indicated that the number of days returned was influenced by sex, distance from urbanization, and age class. However, the covariate of age class was not statistically significant (-1.23, 95% CI = -5.21 – 2.75, *P* = 0.55, Cohen's *d* = -1.36; Figure 4). Using the top-ranked model, both the sex being male and distance from urbanization (Figure 5) had a negative relationship with the number of days returned (Sex: -4.56, 95% CI = -7.31 – -1.8, *P* = 0.002, Cohen's *d* = -1.29; Distance from urbanization: -1.95, 95% CI = -3.34 – -0.57, *P* = 0.007, Cohen's *d* = -1.37). Visual inspection of the analysis for distance from urbanization revealed an outlier, possibly a dispersing mountain lion (Figures 3 and 5); when the outlier was removed, the negative coefficient estimates for distance from urbanization were weakened for both the 1-km and 6-km distances but did not change which variables had statistically significant coefficients.

DISCUSSION

Hazing has been increasingly advocated as a nonlethal solution for resolving human-predator conflicts, but studies evaluating the effectiveness of hazing have produced inconsistent results, including those investigating the use of dogs for hazing. In the case of mountain lions, hazing with dogs has been implemented to manage human-mountain lion conflicts (Elbroch 2020), but efficacy is unknown. Limited evidence suggests that mountain lions might show an aversive reaction to dogs since capturing mountain lions using dogs resulted in a short-term shift in mountain lion locations away from the

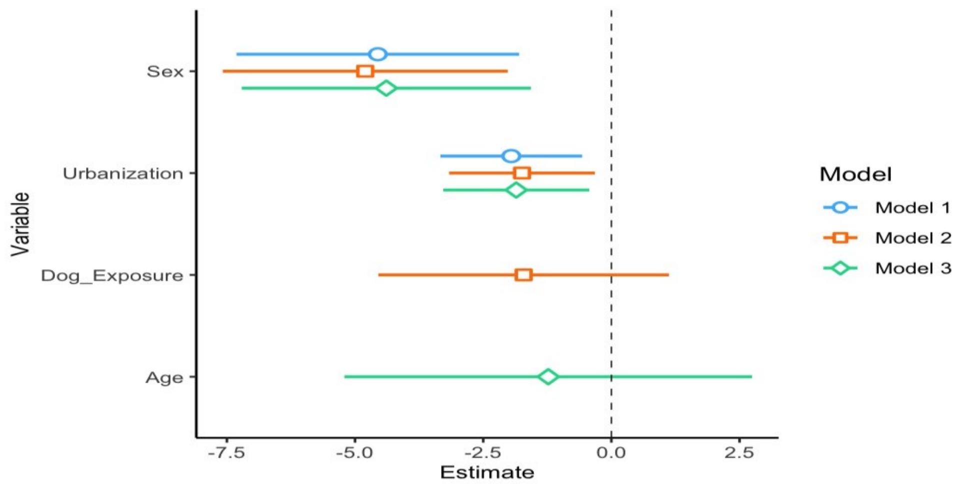

Figure 4. Coefficient estimates based on the top models according to AICc and 95% confidence intervals for the 3 best models for explaining the number of days returned by mountain lions (*Puma concolor*) in California, from 2001-2021, to within a 1-km distance of their capture sites; urbanization refers to the variable of distance from urbanization, age refers to the variable of age class, and dog-exposure refers to the variable of treatment type.

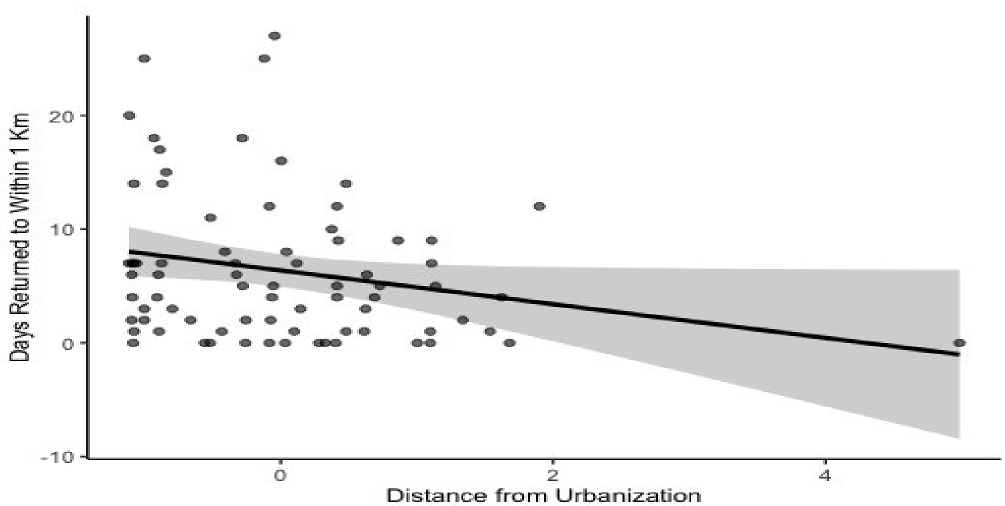

Figure 5. Relation between distance from urbanization and number of days that mountain lions (*Puma concolor*) have returned to within a 1-km distance of their capture sites in California, from 2001-2021, with shaded areas representing 95% confidence intervals.

capture site (Seidensticker et al. 1970), and livestock protection dogs appeared effective in reducing mountain lion predation on domestic livestock (Gonzalez et al. 2012). Moreover, an aversive conditioning attempt with 4 Florida panthers (*Puma concolor*) that involved treeing with dogs, followed by broadcasting sound recordings of baying dogs, appeared to impart some degree of avoidance (McBride et al. 2005).

Nonetheless, we did not find that mountain lions exposed to dogs were displaced farther from the capture site than were mountain lions that were not exposed to dogs. Likewise, dog-exposed mountain lions were not less likely to return to the vicinity of the capture site, at the scale of the presumed location of conflict (1 km) or the scale of mountain lion daily movement patterns (6 km). We did find evidence, though not statistically significant, of a slightly greater displacement of dog-exposed mountain lions the first few days after release, which is consistent with previous work that found a short-term shift in location by mountain lions after being captured using dogs (Seidensticker et al. 1970). Hence, our results are similar to those of studies that reported the lack of a substantial change in behavior of black bears (*U. americanus*) following hazing by dogs at sites of conflict; hazed bears moved somewhat farther from the site than unhazed bears, or delayed their return slightly longer, but almost all hazed bears eventually returned (Beckmann et al. 2004, Leigh and Chamberlain 2008).

Age has influenced the response in other studies of predator hazing; yearling black bears and subadult African lions (*Panthera leo*) were less responsive to hazing than were older animals (Mazur 2010, Petracca et al. 2019). However, we did not find a significant effect of age class on the number of days that mountain lions returned to the capture site. Sex can have an effect as well; adult male African lions were more responsive to hazing than were adult females (Petracca et al. 2019). We found that male mountain lions returned to their capture sites less often than did females. However, because exposure to dogs did not have a significant effect, the cause likely was sex-specific patterns of home range use; male home ranges are larger than those of females (Pierce and Bleich 2003), presumably reducing the number of times a male might be located in a specific area. Prior exposure to humans affected hazing efficacy in black bears and coyotes (*Canis latrans*); those animals conditioned to humans were less responsive to hazing (Mazur et al. 2010, Young et al. 2019). Similarly, we found that mountain lions captured closer to urbanized areas returned more often following release, perhaps because these mountain lions had some degree of exposure to humans.

Our study suffered from an important limitation; we did not compare responses of hazed versus unhazed mountain lions, but instead we capitalized on the hazing effect of dogs used to capture lions, coupled with exposure to barking dogs upon release. The capture and handling experience alone has been considered an aversive agent for black bears (Clark et al. 2002), and the same may be true for mountain lions. The mean distance from the capture site of all mountain lions after 5 days (ca. 7-10 km), exposed to dogs or not, exceeded the mean daily movement distance of mountain lions (6.4 km; Beier et al. 1995). Moreover, this displacement distance was similar to the 8.4-km radius of the size of an average mountain lion home range in California (220 km^2, sexes combined; Pierce and Bleich 2003), assuming a circular shape. These comparisons suggest a substantial displacement from the capture site, even if the mountain lions still returned to the vicinity of the site. Mountain lions show a stronger negative reaction to humans than to dogs (Suraci et al. 2019), and any effect of hazing in our study might be related more to capture stress and proximity to humans rather than to the effect of dogs.

ACKNOWLEDGMENTS

Captures were conducted under authorization of California Department of Fish and Wildlife (CDFW). CDFW staff operated under CDFW approved capture plans and entities outside CDFW operated under CDFW issued scientific collection permits (SC-013416; SC-007303; SC-005636; SC-191710009) and associated IACUC approval (Protocols: 22408; 15341; 16886). We thank all the technicians who have been researching mountain lions in California that have contributed data through the CDFW. Thank you to E. Bolas for input on the analysis. Thank you to R. Baldwin and J. Smith for their advice and comments.

LITERATURE CITED

Alldredge, M. W., F. E. Buderman, and K. A. Blecha. 2019. Human-cougar interactions in the Wildland-urban interface of Colorado's front range. Ecology and Evolution 9(18): 10415-10431.

Ashman, D. L., G. C. Christensen, M. L. Hess, G. K. Tsukamoto, and M. S Wichersham. 1983. The mountain lion in Nevada. Nevada Department of Wildlife Report W-48-15, Reno, NV.

Beckmann, J. P., C.W. Lackey, and J. Berger. 2004. Evaluation of deterrent techniques and dogs to alter behavior of "nuisance" black bears. Wildlife Society Bulletin 32:1141-1146.

Beier, P. 1991. Cougar attacks on humans in the United States and Canada. Wildlife Society Bulletin 19:403-412.

Beier, P., D. Choate, and R. H. Barrett. 1995. Movement patterns of mountain lions during different behaviors. Journal of Mammalogy 76:1056-1070.

Bonnell, M. A., and S. W. Breck. 2017. Using resident-based hazing programs to reduce human-coyote conflicts in urban environments. Human-Wildlife Interactions 11:146-152.

Brady, S. A. 2016. The problematic trend of pseudo-science dictating urban coyote management policy. Proceedings of Vertebrate Pest Conference 27:112-116.

Breck, S. W., S. A. Poessel, and M. A. Bonnell. 2017. Evaluating lethal and nonlethal management options for urban coyotes. Human-Wildlife Interactions 11:133-145.

California Department of Fish and Wildlife. 2020. Annual mountain lion depredation summary table (2011-2019). Accessed 19 September 2021.

Clark, J. E., E. T. van Manen, and M. R. Pelton. 2002. Correlates of success for on-site release of nuisance black bears in Great Smoky Mountains National Park. Wildlife Society Bulletin 30:104-111.

Comeau, N. A. 2013. Evaluation of two methods for aversive conditioning on nuisance activity levels of New Hampshire black bear. Master's thesis, Plymouth State University, Plymouth, NH.

Conover, M. R. 2019. Numbers of human fatalities, injuries, and illnesses in the United States due to wildlife. Human-Wildlife Interactions 13:264-276.

Cunningham, S. C., W. B. Ballard, and H. A. Whitlaw. 2001. Age structure, survival, and mortality of mountain lions in southeastern Arizona. The Southwestern Naturalist 46:76-80.

Cunningham, S. C., C. R. Gustavson, and W. B. Ballard. 1999. Diet selection of mountain lions in southeastern Arizona. Journal of Range Management 52:202-207.

Dellinger, J. A., and S. G. Torres. 2020. A retrospective look at mountain lion populations in California (1906-2018). California Fish and Wildlife 106:66-85.

Elbroch, M. 2020. The cougar conundrum: sharing the world with a successful predator. Island Press, Washington, D.C.

ESRI. 2020. ArcGIS Hub: USA Urban Areas. Accessed 18 December 2021.

Gillen, C. M., F. M. Hammond, and C. M. Peterson. 1994. Evaluation of an aversive conditioning technique used on female grizzly bears in the Yellowstone Ecosystem. International Conference on Bear Research and Management 9:503-512.

Gonzalez, A., A. Novaro, M. Funes, O. Pailacura, M. J. Bolgeri, and S. Walker. 2012. Mixed-breed guarding dogs reduce conflict between goat herders and native carnivores in Patagonia. Human-Wildlife Interactions 6:327-334.

Honeyman, J. 2008. A retrospective evaluation of the effectiveness of aversive conditioning on grizzly bears in Peter Lougheed Provincial Park, Alberta, Canada. Master's thesis, Royal Roads University, Victoria, B.C.

Klip, J. M. K. 2018. Spatial and temporal patterns of a generalist urban carnivore; American black bears (*Ursus americanus*) at Lake Tahoe (CA). PhD dissertation, University of California, Berkeley, CA.

Lackey, C. W., S. W. Breck, B. F. Wakeling, and B. White. 2018. Human-black bear conflicts: a review of common management practices. Human-Wildlife Interactions Monograph 2:1-68.

Laundre, J. W., L. Hernandez, D. Streubel, K. Altendorf, and C. Lopez Gonzalez. 2000. Aging mountain lions using gum-line recession. Wildlife Society Bulletin 28:963-966.

Leigh, J., and M. J. Chamberlain. 2008. Effects of aversive conditioning on behavior of nuisance Louisiana black bears. Human-Wildlife Conflicts 2:175-182.

Mazur, R. L. 2010. Does aversive conditioning reduce human-black bear conflict? Journal of Wildlife Management 74:48-54.

Mazzolli, M., M. E. Graipel, and N. Dunstone. 2002. Mountain lion depredation in southern Brazil. Biological Conservation 105:43-51.

McBride, R., D. K. Jansen, R. McBride, and S. R. Schulze. 2005. Aversive conditioning of Florida panthers by combining painful experiences with instinctively threatening sounds. Proceedings of the Mountain Lion Workshop 8:136.

Nisi, A. C., J. F. Benson, and C. C. Wilmers. 2022. Puma responses to unreliable human cues suggest an ecological trap in a fragmented landscape. Oikos 124:1664-1673.

Ogada, M. O., R. Woodroffe, N. O. Oguge, and L. G. Frank. 2003. Limiting depredation by African carnivores: the role of livestock husbandry. Conservation Biology 17:1521-1530.

Ogden, L. E. 2021. Aversive conditioning: animals and humans learn conflict management. BioScience 71:1201-1207.

Petracca, L. S., J. L. Frair, G. Bastille-Rousseau, J. E. Hunt, D. W. Macdonald, L. Sibanda, and A. J. Loveridge. 2019. The effectiveness of hazing African lions as a conflict mitigation tool: implications for carnivore management. Ecosphere 10:02967.

Pierce, B. M., and V. C. Bleich. 2003. Mountain lion. Pages 744-757 *in* G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Johns Hopkins University Press, Baltimore, MD.

Rauer, G., P. Kaczensky, and F. Knauer. 2003. Experiences with aversive conditioning of habituated brown bears in Austria and other European countries. Ursus 14:215-224.

R-Studio Team. 2020. RStudio: Integrated Development for R. RStudio, PBC, Boston, MA. Accessed 15 April 2022.

Ruth, T. K., K. A. Logan, L. L. Sweanor, M. G. Hornocker, and L. J. Temple. 1998. Evaluating cougar translocation in New Mexico. Journal of Wildlife Management 62(4):1264-1275.

Sampson, L., and L. Van Patter. 2020. Advancing best practices for aversive conditioning (human hazing) to mitigate human-coyote conflicts in urban areas. Human-Wildlife Interactions 14:166-183.

Schirokauer, D. W., and H. M. Boyd. 1998. Bear-human conflict management in Denali National Park and Preserve, 1982-1994. Ursus 10:395-403.

Seidensticker, J. C, IV, M. G. Hornocker, W. V. Wiles, and J. P. Messick. 1970. Mountain lion social organization in the Idaho Primitive Area. Wildlife Monographs 35:1-60.

Shivik, J. A. 2004. Non-lethal alternatives for predation management. Sheep & Goat Research Journal 19:64-71.

Suraci, J. P., J. A. Smith, M. Clinchy, L. Y Zanette, and C. C. Wilmers. 2019. Humans, but not their dogs, displace pumas from their kills: an experimental approach. Scientific Reports 9:12214.

Swan, G. J., S. M. Redpath, S. Bearhop, and R. A. McDonald. 2017. Ecology of problem individuals and the efficacy of selective wildlife management. Trends in Ecology and Evolution 32:518-530.

Torres, S. G., T. M. Mansfield, J. E. Foley, T. Lupo, and A. Brinkhaus. 1996. Mountain lion and human activity in California: testing speculations. Wildlife Society Bulletin 24: 451-460.

United States Department of Agriculture, National Agricultural Statistics Service. 2010. Sheep and goat death loss. Accessed 19 September 2021.

United States Department of Agriculture, National Agricultural Statistics Service. 2011. Cattle death loss. Accessed 19 September 2021.

United States Department of Agriculture. 2017. Census of agriculture. Accessed 20 September 2021.

van Eeden, L. M., M. S. Crowther, C. R. Dickman, D. W. Macdonald, W. J. Ripple, E. G. Ritchie, and T. M. Newsome. 2018. Managing conflict between large carnivores and livestock. Conservation Biology 32:26-34.

VerCauteren, K., M. Lavelle, T. M. Gehring, J. M. Landry, L. Marker, and M. Gompper. 2013. Dogs as mediators of conservation conflicts. Pages 211-238 *in* M. E. Gompper, editor. Free-ranging dogs and wildlife conservation. Oxford University Press, Oxford, U.K.

Vickers, T. W., J. N. Sanchez, C. K. Johnson, S. A. Morrison, R. Botta, T. Smith, and W. M. Boyce. 2015. Survival and mortality of pumas (*Puma concolor*) in a fragmented, urbanizing landscape. PloS ONE 10(7): e0131490.

Wang, Y. Y., T. G. Weiser, and J. D. Forrester. 2019. Cougar (*Puma concolor*) injury in the United States. Wilderness & Environmental Medicine 30:244-250.

Young, J. K., E. Hammill, and S. W. Breck. 2019. Interactions with humans shape coyote responses to hazing. Scientific Reports 9:20046.