Spatiotemporal effects of nuisance black bear management actions in Wisconsin

Zachary Voyles[1,3], **Adrian Treves**[1], **and David MacFarland**[2]

[1]*Nelson Institute for Environmental Studies, The University of Wisconsin, Madison, WI 53706, USA*
[2]*Wisconsin Department of Natural Resources, Rhinelander, WI 54501, USA*

Abstract: American black bears (*Ursus americanus*) triggered complaints from property owners across much of Wisconsin, USA, from 2008 to 2010. Wildlife managers provided technical assistance and live-trapped bears to mitigate nuisances. We examined the longevity of these management actions as measured by the risk (or hazard) that a conflict site would generate a subsequent complaint after live-trapping or technical assistance had been implemented. We observed that as one expanded outward in distance from the original complaint site, the number of days separating a management action and a subsequent complaint decreased. Additionally, the number of bears that were translocated from a conflict location was not associated with decreased hazard. The percentages of locations that did not have a subsequent complaint were nearly identical for both technical assistance and live-trapping interventions. Our technique is a practical one, which could be used to analyze existing agency records. Also, our results could improve the benefit–cost calculations of agencies contemplating new or modified nuisance-response protocols for this bear species and perhaps others.

Key words: American black bear, Cox proportional hazards, human–wildlife conflict, intervention, live-trap, technical assistance, translocation, *Ursus americanus*

DOI: 10.2192/URSUS-D-14-00038.1 ***Ursus 26(1):11–20 (2015)***

Human–bear (*Ursus* spp.) conflict (i.e., complaint resulting from an encounter between a bear(s) and a person or person's property) is an issue that natural resource agencies face annually across the United States and Canada. Although most of these conflicts are not aggressive or predatory in nature, they may amplify perceived risk or decrease acceptance of bears generally (Kasperson et al. 1988, Kellert 1994, Carpenter et al. 2000, Krester et al. 2009, Dickman 2010, Zajac et al. 2012).

The recurring (and, in some cases increasing) problem of conflict between humans and American black bears (*Ursus americanus*) has been attributed to many factors, including growing black bear populations and an increasing number of humans (Williamson 2002, Hristienko and McDonald 2007, Spencer et al. 2007). Although chance encounters do occur, if day-to-day survival of bears becomes difficult, then encounters are more likely to occur (Garshelis 1989, Zack et al. 2003, Obbard et al. 2014). Moreover, bears that frequent human-inhabited areas may become habituated, increasing the likelihood of conflict (Whittaker and Knight 1998). There are also persons who live close to bears and fail to limit bears' access to attractants. Bears may become food-conditioned and may even alter their behavioral ecology when this happens (McCarthy and Seavoy 1994, Peine 2001, Beckmann and Berger 2003a). The complexity of human–bear interactions can make managing human–bear conflicts challenging.

Many mitigation techniques have been tried and tested over the years (e.g., Peine 2001; Clark et al. 2002; Beckmann et al. 2004; Ziegltrum 2004; Gore et al. 2008; Mazur 2010; Baruch-Mordo et al. 2011, 2013). With few exceptions, biologists and managers acknowledge that conflict mitigation actions are often short-lived because of competing external factors. Two widely used conflict mitigation strategies deserve scientific evaluation: live-trapping with relocation (translocation), and public education.

Translocation of nuisance bears has been a common method for mitigating damage caused by black bears throughout the United States (Stowell and Willging 1992, Linnell et al. 1997, Witmer and Whittaker 2001, Spencer et al. 2007). The efficacy of translocating carnivores, generally, has

---

[3]email: zvoyles@gmail.com

been questioned in recent years (Fontúrbel and Simonetti 2011). Evaluating the success of black bear translocations has been measured by monitoring translocated bears post-release (Alt et al. 1977, McArthur 1981, Massopust and Anderson 1984, Fies et al. 1987, Shull 1994, Linnell et al. 1997, Landriault 1998). Results varied, even within studies, indicating the potential for translocated bears to either cease or continue causing problems. For example, Landriault (1998) found that anywhere from 10% to 48% of relocated nuisance bears in South Ontario, Canada, were repeat offenders. Biologists have also noted the extraordinary ability of black bears to home back to their capture site after relocation (Harger 1970, Rutherglen and Herbison 1977, Massopust and Anderson 1984, Rogers 1986, Fies et al. 1987, Linnell et al. 1997, Landriault 1998). Nevertheless, many managers continue to rely on translocation as a method for mitigating human–bear conflict.

Education (e.g., Bear-Aware, outreach, extension, technical assistance) has been widespread in bear management programs, and many public agencies and non-profit organizations continue to provide educational materials to help the public coexist with bears (Hristienko and McDonald 2007, Spencer et al. 2007). Research has shown, however, that educational programs with goals of mitigating or preventing human–bear conflict were rarely critically reviewed (Gore et al. 2008). When educational programs have been critically evaluated, studies found measurable effects. These effects included increased public support for direct management interventions and increased conflict-risk perceptions (Gore et al. 2008, Merkle et al. 2011a). Zajac et al. (2012) and Slagle et al. (2013) showed that study subjects increased acceptance of bears when informational interventions noted benefits that people gain from bears, and acceptance of bears declined when information only included nuisance control recommendations.

Recent studies have given new insights into human–bear conflicts through spatiotemporal investigations (e.g., Wilson et al. 2005, Baruch-Mordo et al. 2008, Merkle et al. 2011b). These studies have shown that conflicts were not ubiquitous, and Krester et al. (2009) showed that human perceptions toward human–bear interactions exhibited spatial clustering. Our study explored a new vein of spatiotemporal study where management interventions and complaints served as the foci.

We examined the results of U.S. Department of Agriculture - Animal and Plant Health Inspection Service, Wildlife Services branches in Wisconsin (WS) responses to residents' complaints about residential (non-agricultural) black bear nuisances from 2008 through 2010. We compared 2 interventions (informal technical assistance conducted by telephone vs. live-trapping bears) and their effects on spatiotemporal patterns of subsequent nuisance complaints. Wildlife Services addressed complaints involving agricultural damage using a distinctly different set of procedures (Wildlife Damage Abatement and Claims Program) and were therefore excluded from our analyses. We defined the spatiotemporal effects of WS interventions as the risk for a subsequent complaint in the vicinity ($\leq$23.31-km^2 area) of the original complaint location. Our definition of spatiotemporal effect mirrored that of Harper et al. (2008). We also investigated whether translocating a greater or lesser number of bears from the same vicinity was associated with changes in the risk of future complaints in that vicinity.

We predicted that both technical assistance and translocation would display diminished efficacy over space and time (i.e., that they were spatiotemporally limited). To test this prediction, we hypothesized that the time interval ($t_1 - t_0$) between a management response (t_0) and a subsequent complaint (t_1) was negatively correlated with the distance between the management response location x_0 and the subsequent nearest complaint location x_1. We also predicted that future complaints would decrease concomitantly with bear translocations. Our second hypothesis was that the time interval ($t_1 - t_0$) between when a live-trap was set (t_0) and when a subsequent complaint was reported (t_1) increased if more bears were translocated from the vicinity of the management response location.

Methods

From 2008 to 2010, residential complaints about black bears were telephoned into WS offices in Rhinelander and Waupun, Wisconsin. Providing technical assistance over the phone was standard protocol for minor conflicts. If bear nuisance continued despite complainants' compliance with WS recommendations, live-trapping was performed on or near a complainant's property. Or, if a conflict was perceived by WS as dangerous for a person or bear, then live-trapping was performed. Bears were euthanized in the rare case of an extreme safety concern. Although bears were not always captured when live-trapping was used, most (>90%) successful captures resulted in bear relocation. Captured bears were transported ≥32 km from the capture site and released onto large tracts of public land. Sex of captured individuals was unknown unless cubs were present. Bears were not hazed post-release. Wildlife Services filed complaint reports following standard operating procedures regardless of the type of mitigation provided. We recorded events in which WS used either live-trapping or technical assistance.

We obtained addresses of complainants from WS reports and entered them into a Microsoft Excel (Microsoft Corp., Redmond, Washington, USA) spreadsheet. We used an ArcMap geo-location application, which used an Environmental Systems Research Institute server database as a reference to plot addresses (ArcMap 10.0; Environmental Systems Research Institute, Redlands, California, USA). Addresses that ArcMap could not plot to an 80% level of assurance were not mapped, but we did keep them for property-level analysis if they could be uniquely identified. We truthed locations that were plotted between 80% and 98% accuracy using Google (Google, Inc., Mountain View, California, USA) and Bing Maps (Microsoft Corp.). We subsequently generalized plotted addresses to Public Land Survey System (PLSS) sections (2.59 km^2) to comply with U.S. Department of Agriculture rules regarding personally identifiable information.

In addition to complaint location, we recorded the date of the complaint. We omitted records that documented subsequent complaints at a location on the same day. We did this to allow WS enough time to respond to a bear complaint and to help avoid pseudoreplication by artificially inflating the sample. We also removed repeat complaints that originated from the same property within the same calendar year to avoid biasing our results with repeat locations that may have had subsequent conflict because of failing to comply with WS recommendations. By removing these, we also avoided taking multiple measures for any one location. We excluded properties with live-trapping and on-site release, euthanasia, or cubs taken to a rehabilitation center from our analyses of Hypothesis 2 because it dealt expressly with translocation; but, we did retain these cases for our analysis of Hypothesis 1.

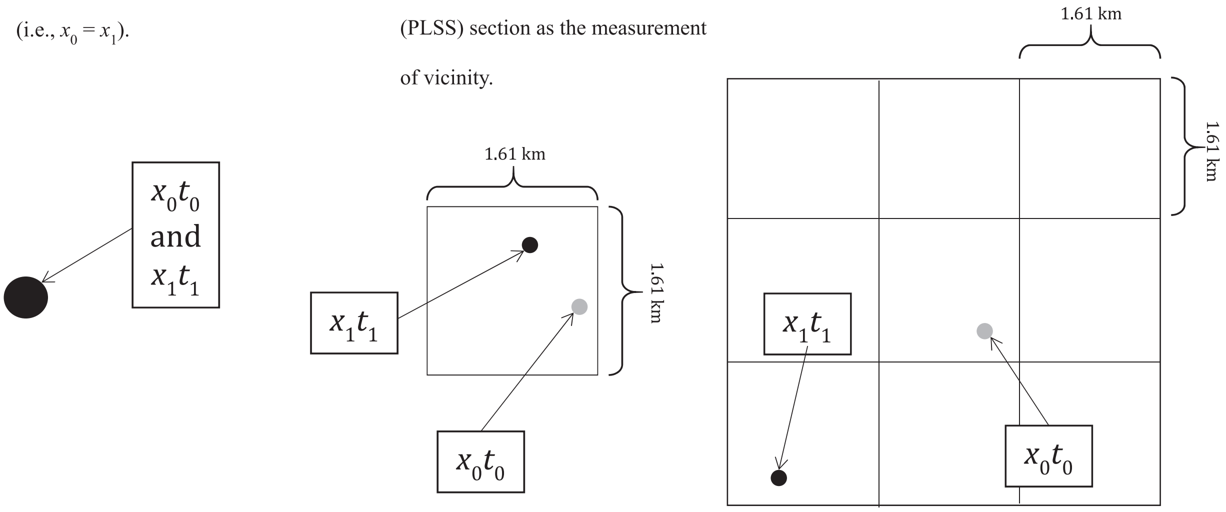
From our data set, we identified management interventions (technical assistance or live-trapping) at a given location (x_0) and time (t_0) and then identified subsequent nuisance complaints in the vicinity (x_1t_1). Thus, each observation received a measurement corresponding to the number of days between a management intervention (t_0) and a subsequent complaint (t_1) within a calendar year. We referred to this measurement as the observed latency period ($t_1 - t_0$). If no subsequent complaint occurred after an intervention, we assigned a latency period of 365 days, and that observation was censored. We did not drop censored locations from analysis, but we did binary-code them to indicate whether or not a subsequent complaint was made.

We chose 3 spatial scales (vicinities) within which we identified subsequent complaints: (A) complainant's property, (B) PLSS section of 2.59 km^2, and (C) 23.31-km^2 block of 9 PLSS sections (Fig. 1). We used ArcMap v. 10.0 to perform the spatial query to locate x_1t_1 at the PLSS levels, and a logical query in Excel to locate x_1t_1 at the property level.

Our statistical analyses followed those of event history analysis (Broström 2012). The Nelson–Aalen estimator of the cumulative hazard function is used in survival analyses and allows for censoring by incorporating unobserved responses into the estimate. Rather than estimating survival (s), though, it provides a hazard estimate (1 − s). It is a conditional measure of hazard; in this case, this means that given a management intervention, it estimated the cumulative proportion of locations at risk for a subsequent complaint at any given time. The hazard estimates were quantified using our previously calculated latency periods. The estimator is

$$\hat{H}(t) = \sum_{t_j \le t} \left[\frac{\text{Number of subsequent complaints at time } j = d_j}{\text{Number of locations at risk at time } j = r_j} \right]$$

We refined this hazard estimator, adding variables using a Cox proportional hazards regression (Broström 2012). We incorporated vicinity (z_1) and the number of bears translocated (z_2) in the vicinity of x_0 between t_0 and t_1 into the estimator so we could compare hazard at different vicinities (Hypothesis 1) and hazard's association with the number of bears translocated (Hypothesis 2). For some PLSS 2.59-km^2 sections, multiple properties received management interventions within a year, and thus some sections had multiple latency periods. For this reason, we added a categorical variable (z_3) to identify interventions within 2.59-km^2 sections that followed prior intervention(s) on other properties (1)



A. The initial management-response location (x_0t_0) and subsequent complaint location (x_1t_1) using the complainant's property as the measurement of vicinity (i.e., $x_0 = x_1$).

B. The initial management-response location (x_0t_0) and subsequent complaint location (x_1t_1) using the Public Land Survey System's (PLSS) section as the measurement of vicinity.

C. The initial management-response location (x_0t_0) and subsequent complaint location (x_1t_1) using a block of 9 PLSS sections as the measurement of vicinity.

Fig. 1. Management response location (x_0t_0) and subsequent complaint location (x_1t_1) for nuisance complaints about black bears in Wisconsin (USA), 2008–2010.

or that were unique at the time of their implementation (0). Wisconsin WS mitigation efforts and techniques underwent a dramatic shift around the first of August because of the developmental changes in field corn (*Zea mays;* Voyles 2013). Therefore, we ran an additional regression using a binary variable (z_4) to code for management responses that occurred before 1 August (0) or after 1 August (1). Cox's regression formula is

$$h(t|z) = h_0(t)e^{\{\beta' z\}}$$

We performed Wald significance tests using R software (R Core Team 2013) and statistical package eha (Broström 2013) for our analyses of Hypotheses 1 and 2. We performed all tests of significance with alpha (α) set to 0.05. We defined tendency as having a probability where $\alpha < P < 2\alpha$. Tests presented the risk of subsequent complaint in the form of "relative hazard." Relative hazard represented hazard level relative to a reference. In the case of categorical variables (i.e., z_1, z_3, and z_4), one of the categories served as the reference. For a continuous variable (i.e., z_2), no hazard (i.e., a value of "0") served as the default reference.

We acknowledge that there were other potential confounding factors that could have contributed to latency periods (e.g., local bear densities, natural food availability, or the type of conflict) that we could not account for. Though these factors were relevant, they were not quantifiable from the records available to us; and, though potentially limiting, we feel their omission predisposes our technique to managers looking for rapid assessment.

Results

From approximately 3,460 complaint records filed by WS from 2008 to 2010 (Engstrom et al. 2008, 2009, 2010; Z. Voyles, unpublished data), we calculated 2,532 latency periods within the larger 2 vicinities (2.59 km^2 and 23.31 km^2) plus an additional 137 for properties that could not be mapped reliably but were identifiably unique. Most locations had no subsequent complaint and were thus censored. However, the number of subsequent complaints increased as our measure of vicinity expanded (Table 1).

A Cox regression yielded a significant positive correlation with vicinity (z_1). Whether management

Table 1. Number of management responses to complaints about black bears (x_0t_0), subsequent complaints (x_1t_1), and the percentage of locations that did not have subsequent complaints (censored) for 3 vicinity levels and 2 management response types in Wisconsin, USA, 2008–2010.

	Property			2.59 km^2			23.31 km^2		
	Live-trapping	Technical assistance	Total	Live-trapping	Technical assistance	Total	Live-trapping	Technical assistance	Total
Management responses	722	1,947	2,669	720	1,812	2,532	720	1,812	2,532
Subsequent complaints	66	112	178	145	412	557	322	812	1,134

interventions consisted of live-trapping or technical assistance alone, the relative hazard for a subsequent complaint was higher by a factor of 3.6 (Rel. hazard = 3.61, SE = 0.09, $P < 0.001$) when we expanded the vicinity from the property level to 2.59 km^2; and by a factor of 8.7 (Rel. hazard = 8.69, SE = 0.08, $P < 0.001$) when we expanded it to 23.31 km^2. In short, risk of a subsequent complaint progressively increased outward from the location of the management intervention (Table 2).

Hazard at the property level was significantly higher when more bears were removed (Rel. hazard = 1.28, SE = 0.09, P = 0.004). That is, relative hazard for a property increased by a factor of 1.28/translocated bear. An average of 241 (SD = 7) properties per year had live-trapping. Of those, 142 (SD = 7) resulted in translocation; and, an average of 108 (SD = 12) of those had only 1 bear translocated, while 16 (SD = 0.5) had 2 bears and 18 (SD = 5) had ≥3 bears translocated. There was no significant association between the number of translocations and hazard at either the 2.59-km^2 or 23.31-km^2 levels (Table 3).

Table 2. Cox regression analysis using vicinity (z_1) as a predictor variable for hazard of a subsequent complaint in the vicinity of the initial management response to complaints about black bears in Wisconsin, USA, 2008–2010. Rel. hazard is hazard relative to the reference (property level). Significance is defined at $\alpha = 0.05$.

Variable z_1	$\bar{x}$	Coeff.	Rel. hazard	SE	Wald P
Property	0.418	0.000	1 (reference)		
2.59 km^2	0.337	1.283	3.608	0.086	<0.001
23.31 km^2	0.244	2.162	8.685	0.081	<0.001

When we examined the aftermath of prior management interventions (z_3) within a PLSS 2.59-km^2 section, we found an approximate 2–3-fold increase in hazard if another property within a section had received prior intervention(s) that year (Table 4). Forty 2.59-km^2 sections had multiple properties with live-trapping interventions, while 267 had multiple technical assistance calls (not counting those properties where technical assistance was given in tandem with live-trapping). Allowing for standard error, hazard for 23.31-km^2 vicinities was approximately 2.0 times higher if the central 2.59-km^2 section had either prior technical assistance or live-trapping (SE = 0.087, $P < 0.001$; SE = 0.208, $P = 0.003$). Hazard was also higher within the 2.59-km^2 section itself, although the increase differed between technical assistance and live-trapping (2.9 for 2.59-km^2 sections having had technical assistance prior, and 2.0 for 2.59-km^2 sections having had live-trapping prior; SE = 0.109, $P < 0.001$; SE = 0.281, $P = 0.011$).

Season (z_4) and hazard for subsequent complaints were not significantly associated. However, we did see a tendency for season to be associated with property-level hazard when WS responded with live-trapping. Hazard for a subsequent complaint was nearly two-thirds less if live-trapping took place after 1 August (Rel. hazard = 0.353, SE = 0.592, $P = 0.078$).

Table 3. Cox regression analysis using the number of translocated black bears (z_2) as a predictor for hazard of a subsequent complaint about bears in the vicinity in Wisconsin, USA, 2008–2010. Rel. hazard is hazard relative to zero bears having been translocated. Significance is defined at $\alpha = 0.05$.

Variable z_2	$\bar{x}$	Coeff.	Rel. hazard	SE	Wald P
Per translocation from property	0.863	0.248	1.282	0.09	0.004
Per translocation from 2.59 km^2	0.878	−0.024	0.976	0.08	0.766
Per translocation from 23.31 km^2	0.876	0.005	1.005	0.05	0.932

Table 4. Cox regression analysis using previous management response (z_3; yes or no) as the predictor variable for hazard of a subsequent complaint about black bears in Wisconsin, USA, 2008–2010. Rel. hazard is hazard relative to the reference (no previous management response). Significance is defined at $\alpha = 0.05$. Vicinities having had a previous response are coded "1"; those not are "0."

	2.59 km^2 live-trapping		2.59 km^2 technical assistance		23.31 km^2 live-trapping		23.31 km^2 technical assistance	
Variable z_3	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**
Mean	0.957	0.043	0.903	0.097	0.963	0.037	0.911	0.089
Coeff.	0.000	0.716	0.000	1.073	0.000	0.622	0.000	0.691
Rel. hazard	1 (reference)	2.045	1 (reference)	2.924	1 (reference)	1.863	1 (reference)	1.996
SE		0.281		0.109		0.208		0.087
Wald *P*		0.011		<0.001		<0.01		<0.001

Discussion

We predicted that both technical assistance and translocation would display diminished efficacy over space and time. Our results support this prediction and showed that hazards for subsequent nuisance complaints after management interventions were consistently greater and latency periods shorter at larger spatial scales (Table 2). Spatiotemporal effects were exemplified by our finding that subsequent conflict hazard was not uniform over space or time (Fig. 2). Managers should not expect efforts directed toward an individual property to necessarily prevent conflict on nearby properties for an extended period of time. This finding helped to substantiate Don Carlos et al.'s (2009:175) claim that "Traditional approaches to conflict management are largely only short-term solutions…" Although efforts directed toward an individual bear at a unique property might have relieved immediate conflict potential, our data suggest that other bears and other properties eventually experienced conflict regardless of prior intervention. If bear managers want to increase management effectiveness, they must acknowledge the spatiotemporal limitations of management actions. Acknowledging this can help better allocate funds, staff, and other finite resources.

Prior management interventions (technical assistance and live-trapping) on nearby properties were associated with increased hazard both within the 2.59-km^2 sections and the 23.31-km^2 blocks (Table 4). When multiple property owners complained in an area, it may have been because that area was prone to conflict and thus management interventions (of either type) were simply more frequent. Or, previous conflicts might have influenced individuals' perceptions of risk (Gore 2004, Krester et al. 2009, Siemer et al. 2009). Social psychologists have studied "contagion" theories, which explore the ways in which perceived risk spreads through communities (Scherer and Cho 2003). We propose that some persons or local areas that received management assistance were more likely to seek management assistance in the future because of social contagion processes, which may have enhanced conflict awareness or perceived risk.

Increased hazard could have also been due to human-induced disruptions in bear ecology (Beckmann and Berger 2003a), varied inter-urban densities (Baruch-Mordo et al. 2008), or natural food shortages (Garshelis 1989, Poulin et al. 2003). There is also a possibility that repeat complaints were about a different type of nuisance behavior (e.g., birdseed initially, garbage second). In such a case, the initial management intervention may have curbed the first nuisance behavior while failing to prevent future conflict. Also, some management interventions were aimed at preventing conflict more generally (i.e., technical assistance); others were directed at an individual bear (i.e., translocation). The former intervention may have translated to reduced conflict from *any* bear, but the latter could only be expected to have stopped the *offending* bear.

In Wisconsin, we found that neither live-trapping nor translocation proved to be an effective means of complaint reduction. We found that live-trapping was not associated with reduced hazard at any of the spatial scales we measured. Neither did we find any significant reduction in hazard for any number of bear translocations, despite our prediction that future complaints would decrease concomitantly with bear translocations. Our hazard results may have looked different if sex or age information were included because several studies have shown sex or age components to bear nuisance behavior (Garshelis 1989, Beckmann and Berger 2003b, Treves et al. 2010). However, this information was

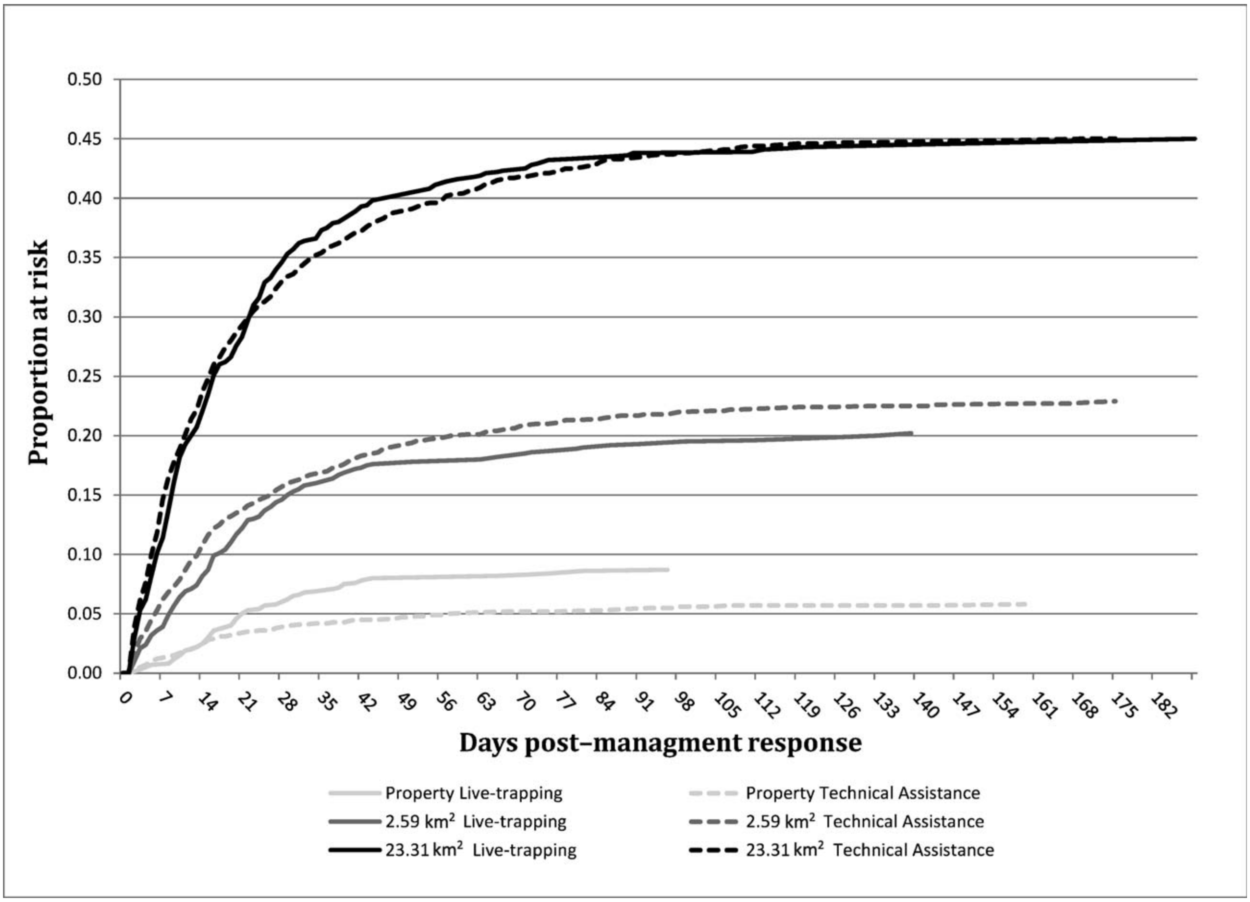


Fig. 2. Proportion of human–bear conflict sites in Wisconsin, USA, 2008–2010, at risk of subsequent conflict post–management intervention (technical assistance or live-trapping) within a given vicinity (property, 2.59 km^2, 23.31 km^2) of the conflict site. Proportion at risk was calculated by taking 1 − s (i.e., 1 − survival) and is a measure of hazard.

not observable firsthand by WS personnel in most circumstances, and such information was often not available before decisions had to be made. Natural processes, different offending bears, and enhanced conflict awareness or perceived risk could have also limited translocation effectiveness.

Although we found no statistically significant association between season and hazard, we did observe a tendency for properties that had live-traps placed after 1 August to be two-thirds less likely to report subsequent conflict than properties having live-traps placed prior to 1 August. This was partly because complaints reported after 1 August had less time to experience future conflict before bears began denning. Wisconsin's annual bear harvest occurred from early September to mid-October, and this could have curtailed nuisance behavior, although recent studies question hunting's capacity to reduce conflict (Treves et al. 2010, Obbard et al. 2014). It might also have been due to the seasonal nature of bear conflicts in Wisconsin, where non-agricultural complaints were more frequent prior to 1 August before field corn reached the palatable milk stage and before hard mast became readily available (Voyles 2013).

The feasibility and requirements of management actions such as technical assistance and translocation differ. Technical assistance is a speedy response and is more easily staffed than live-trapping and translocation, which requires travel, specialized equipment, and staff trained to handle and release or possibly euthanize bears. Given a choice devoid of circumstances, managers would choose technical assistance. In reality, however, circumstances surrounding human–black bear nuisances (such as threats to health and human safety) may limit the options managers have. Given our results, though, we would suggest managers consider using technical assistance more often and limit live-trapping and translocation when circumstances allow. We strongly recommend that managers thoroughly evaluate the circumstances in which they implement live-trapping; and, when live-trapping is implemented, that they monitor its effectiveness.

On account of inconsistencies with WS bear-complaint reports, we were unable to include complaint types in our analyses. We would advise all managing agencies to record the nature of bear complaints consistently and concisely, while leaving room for extemporaneous descriptions. It is also important that reporting forms avoid ambiguous or vague descriptors such as "property damage." We encourage managers to use electronic records as opposed to written records if circumstances allow, or to enter hand-written reports into electronic databases at minimum. Further, new technologies are allowing the public to self-report conflicts (e.g., British Columbia Conservation Foundation's Wildlife Alert Reporting Program). Self-reporting programs could help agency staff strategize conflict-mitigation efforts, including where best to allocate resources in the field. We also advocate locally based proactive education and enforcement. There are communities that have experienced positive results from such programs (Peine 2001, Baruch-Mordo et al. 2011).

Our methods in this study were practical, and can be used retroactively by bear managers and biologists to analyze existing records of human–bear conflict. Differentiating the spatiotemporal limits of management actions can lead to better decision-making, help create evidence-based action plans, and ultimately save resources. Unfortunately, the utility of our technique did not accommodate some potentially confounding factors that may have affected our observed latency periods. Future hazard studies would benefit from including factors such as local bear densities, food availability, property characteristics, and conflict types.

Acknowledgments

We thank members of the Carnivore Coexistence Lab at the University of Wisconsin – Madison, Dr. D. Drake, and 5 anonymous reviewers for evaluating drafts of this manuscript. This material was made possible, in part, by financial assistance from the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS). It may not necessarily express APHIS's views. Additional funding for this research was provided by the Nelson Institute for Environmental Studies, the Derse Family Foundation, and the Jack H. Berryman Institute.

Literature cited

Alt, G.L., G.J. Matula, Jr., F.W. Alt, and J. Lindzey. 1977. Movements of translocated nuisance black bears of northeastern Pennsylvania. Transactions of the Northeast Fish and Wildlife Conference 40:119–126.

Baruch-Mordo, S., S.W. Breck, K.R. Wilson, and J. Broderick. 2011. The carrot or the stick? Evaluation of education and enforcement as management tools for human–wildlife conflicts. PLoS ONE 6:e15681. doi:10.1371/journal.pone.0015681.

———, ———, ———, and D.M. Theobald. 2008. Spatiotemporal distribution of black bear–human conflicts in Colorado, USA. Journal of Wildlife Management 72:1853–1862.

———, C.T. Webb, S.W. Breck, and K.R. Wilson. 2013. Use of patch selection models as a decision support tool to evaluate mitigation strategies of human–wildlife conflict. Biological Conservation 160:263–271.

Beckmann, J.P., and J. Berger. 2003a. Rapid ecological and behavioural changes in carnivores: The responses of black bears (*Ursus americanus*) to altered food. Journal of Zoology 261:207–212.

———, and ———. 2003b. Using black bears to test ideal-free distribution models experimentally. Journal of Mammalogy 84:594–606.

———, ———, and C.W. Lackey. 2004. Evaluation of deterrent techniques and dogs to alter behavior of "nuisance" black bears. Wildlife Society Bulletin 32: 1141–1146.

Broström, G. 2012. Event history analysis with R. First edition. Taylor & Francis, Boca Raton, Florida, USA.

———. 2013. eha: Event history analysis. R package version 2.3-1. http://CRAN.R-project.org/package=eha. Accessed 19 Nov 2013.

Carpenter, L.H., D.J. Decker, and J.F. Lipscomb. 2000. Stakeholder acceptance capacity in wildlife management. Human Dimensions of Wildlife 5:5–19.

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

Dickman, A.J. 2010. Complexities of conflict: The importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13:458–466.

DON CARLOS, A., A. BRIGHT, T. TEEL, AND J. VASKE. 2009. Human–black bear conflict in urban areas: An integrated approach to management response. Human Dimensions of Wildlife 14:174–184.

ENGSTROM, P., B. WILLGING, AND D. RUID. 2008. Black bear damage and nuisance complaints. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Sun Prairie, Wisconsin, USA.

———, ———, AND ———. 2009. Black bear damage and nuisance complaints. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Sun Prairie, Wisconsin, USA.

———, ———, AND ———. 2010. Black bear damage and nuisance complaints. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Sun Prairie, Wisconsin, USA.

FIES, M., D. MARTIN, AND G. BLANK, JR. 1987. Movements and rates of return of translocated black bears in Virginia. International Conference on Bear Research and Management 7:369–372.

FONTÚRBEL, F.E., AND J.A. SIMONETTI. 2011. Translocations and human–carnivore conflicts: Problem solving or problem creating? Wildlife Biology 17:217–224.

GARSHELIS, D.L. 1989. Nuisance bear activity and management in Minnesota. Pages 169–180 in M. Bromley, editor. Bear–people conflicts: Proceedings of a symposium on management strategies. Northwest Territories Department of Natural Resources, Yellowknife, Northwest Territories, Canada.

GORE, M.L. 2004. Comparison of intervention programs designed to reduce human–bear conflict: A review of literature. Cornell University, Department of Natural Resources, Human Dimensions Research Unit Publication Series No. 04-4, Ithaca, New York, USA.

———, B.A. KNUTH, C.W. SCHERER, AND P.D. CURTIS. 2008. Evaluating a conservation investment designed to reduce human–wildlife conflict. Conservation Letters 1: 136–145.

HARGER, E. 1970. A study of homing behavior of black bears. Thesis, Northern Michigan University, Marquette, Michigan, USA.

HARPER, E., W.J. PAUL, L.D. MECH, AND S. WEISBERG. 2008. Effectiveness of lethal, directed wolf-depredation control in Minnesota. Journal of Wildlife Management 72:778–784.

HRISTIENKO, H., AND J.E. MCDONALD. 2007. Going into the 21st Century: A perspective on trends and controversies in the management of the American black bear. Ursus 18:72–88.

KASPERSON, R.E., O. RENN, P. SLOVIC, H.S. BROWN, J. EMEL, R. GOBLE, J.X. KASPERSON, AND S. RATICK. 1988. Social amplification of risk: A conceptual framework. Risk Analysis 8:177–187.

KELLERT, S.R. 1994. Public attitudes towards bears and their conservation. International Conference on Bear Research and Management 9:43–50.

KRESTER, H.E., P.D. CURTIS, AND B.A. KNUTH. 2009. Landscape, social, and spatial influences on perceptions of human–black bear interactions in the Adirondack Park, NY. Human Dimensions of Wildlife 14:393–406.

LANDRIAULT, L.J. 1998. Nuisance black bear (*Ursus americanus*) behaviour in central Ontario. Thesis, Laurentian University, Sudbury, Ontario, Canada.

LINNELL, J., R. AANES, J.E. SWENSON, J. ODDEN, AND M. SMITH. 1997. Translocation of carnivores as a method for managing problem animals: A review. Biodiversity and Conservation 6:1245–1257.

MASSOPUST, J.L., AND R.K. ANDERSON. 1984. Homing tendencies of translocated nuisance black bears in northern Wisconsin. Eastern Black Bear Workshop 7: 66–73.

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

MCARTHUR, K.L. 1981. Factors contributing to effectiveness of black bear transplants. Journal of Wildlife Management 45:102–110.

MCCARTHY, T.M., AND R.J. SEAVOY. 1994. Reducing nonsport losses attributable to food conditioning: Human and bear behavior modification in an urban environment. International Conference on Bear Research and Management 9:75–84.

MERKLE, J.A., P.R. KRAUSMAN, AND M.L. BOOTH. 2011a. Behavioral and attitudinal change of residents exposed to human–bear interactions. Ursus 22:74–83.

———, ———, N.J. DECESARE, AND J.J. JONKEL. 2011b. Predicting spatial distribution of human–black bear interactions in urban areas. Journal of Wildlife Management 75:1121–1127.

OBBARD, M.E., E.J. HOWE, L.L. WALL, B. ALLISON, R. BLACK, P. DAVIS, L. DIX-GIBSON, M. GATT, AND M.N. HALL. 2014. Relationships among food availability, harvest, and human–bear conflict at landscape scales in Ontario, Canada. Ursus 25:98–110.

PEINE, J.D. 2001. Nuisance bears in communities: Strategies to reduce conflict. Human Dimensions of Wildlife 6:223–237.

POULIN, R., J. KNIGHT, M. OBBARD, AND G. WITHERSPOON. 2003. Nuisance Bear Review Committee report and recommendations. Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada.

R CORE TEAM. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/. Accessed 19 Nov 2013.

Rogers, L.L. 1986. Homing by radio-collared black bears (*Ursus americanus*) in Minnesota. The Canadian Field-Naturalist 100:350–353.

Rutherglen, R.A., and B. Herbison. 1977. Movements of nuisance black bears (*Ursus americanus*) in southern British Columbia. Canadian Field Naturalist 91:419–422.

Scherer, C.W., and H. Cho. 2003. A social network contagion theory of risk perception. Risk Analysis 23: 261–267.

Shull, S. 1994. Management of nuisance black bears (*Ursus americanus*) in the interior highlands of Arkansas. Thesis, University of Arkansas, Fayetteville, Arkansas, USA.

Siemer, W.F., P.S. Hart, D.J. Decker, and J.E. Shanahan. 2009. Factors that influence concern about human–black bear interactions in residential settings. Human Dimensions of Wildlife 14:185–197.

Slagle, K., R. Zajac, J. Bruskotter, R. Wilson, and S. Prange. 2013. Building tolerance for bears: A communications experiment. Journal of Wildlife Management 77:863–869.

Spencer, R.D., R.A. Beausoleil, and D.A. Martorello. 2007. How agencies respond to human–black bear conflicts: A survey of wildlife agencies in North America. Ursus 18:217–229.

Stowell, L.R., and R.C. Willging. 1992. Bear damage to agriculture in Wisconsin. Proceedings of the Eastern Wildlife Damage Control Conference 5:96–104.

Treves, A., K.J. Kapp, and D.M. MacFarland. 2010. American black bear nuisance complaints and hunter take. Ursus 21:30–42.

Voyles, Z. 2013. Spatiotemporal tendencies of human–black bear conflicts and the effectiveness of current conflict mitigation strategies in Wisconsin. Thesis, University of Wisconsin, Madison, Wisconsin, USA.

Whittaker, D., and R.L. Knight. 1998. Understanding wildlife responses to humans. Wildlife Society Bulletin 26:312–317.

Williamson, D. 2002. In the black: Status, management, and trade of the American black bear (*Ursus americanus*) in North America. TRAFFIC North America, World Wildlife Fund, Washington, DC, USA.

Wilson, S.M., M.J. Madel, D.J. Mattson, J.M. Graham, J.A. Burchfiled, and J.M. Belsky. 2005. Natural landscape features, human-related attractants, and conflict hotspots: A spatial analysis of human–grizzly bear conflicts. Ursus 16:117–129.

Witmer, G.W., and D.G. Whittaker. 2001. Dealing with nuisance and depredating black bears. Western Black Bear Workshop 7:73–81.

Zack, C.S., B.T. Milne, and W.C. Dunn. 2003. Southern Oscillation Index as an indicator of encounters between humans and black bears in New Mexico. Wildlife Society Bulletin 31:517–520.

Zajac, R.M., J.T. Bruskotter, R.S. Wilson, and S. Prange. 2012. Learning to live with black bears: A psychological model of acceptance. Journal of Wildlife Management 76:1331–1340.

Ziegltrum, G.J. 2004. Efficacy of black bear supplemental feeding to reduce conifer damage in western Washington. Journal of Wildlife Management 68: 470–474.

Received: 16 December 2014
Accepted: 1 April 2015
Associate Editor: McDonald