Do public complaints reflect trends in human–bear conflict?

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Abstract: Minimizing conflicts with humans is a necessary component of the management of American black bears (*Ursus americanus*) across most of their range. The number of complaints about conflicts with black bears is commonly used to infer trends in the actual frequency or severity of human–bear conflict, and even trends in bear population size. However, the number of complaints received by management agencies is a function of both the frequency of and the reporting rate for conflicts, and the reporting rate may change over time. We tested for effects of food availability, numbers of bears harvested, and management regime changes on 3 measures of human–bear conflict: (1) public complaints, (2) traps set to capture bears involved in conflicts, and (3) bears killed in defense of property in Parry Sound, Ontario, Canada, 1992–2008. All measures of human–bear conflict were inversely related to food availability. Complaints increased following a controversial change in management (cancellation of the spring hunting season), but numbers of traps set and bears killed were not affected. We suggest that an increase in the reporting rate was largely responsible for the increase in complaints following the spring hunt cancellation because (1) an effect on the actual frequency or severity of human–bear conflict should also have been detected in data for traps set but was not, and (2) neither the number nor the sex ratio of harvested bears changed when the spring hunt was cancelled, so the effect of harvest on population size and sex ratio was not altered by the management regime change. Trends in the actual frequency and severity of human–bear conflict should not be inferred from trends in complaint data unless factors that could affect the reporting rate for conflicts are accounted for.

Key words: American black bear, food availability, harvest, human–bear conflict, human–wildlife conflict, Ontario, social carrying capacity, *Ursus americanus*

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Conflicts between humans and American black bears (*Ursus americanus*) can inflict major economic costs and can pose risks to human safety. To reduce costs and risks, wildlife managers and policy-makers require information about how rates of human–bear conflict change over time. In most North American jurisdictions, the frequency of human–black bear conflict is measured using the number of public complaints (Spencer et al. 2007). Complaint data may include reports of many types of interactions, ranging from dangerous encounters or property damage to mere sightings of bears near developed areas (Spencer et al. 2007), and are a function of both the frequency of, and the reporting rate for, such interactions. For example, in Minnesota the reporting rate for nuisance activity by black bears varied among years (Garshelis 1989). Nevertheless, bear researchers and managers frequently infer trends in human–bear conflict and evaluate the effectiveness of management actions designed to reduce conflict based on trends in complaint data (Witmer and Whittaker 2001, Gore et al. 2006a, Hristienko and McDonald 2007). Such inferences rely on the assumption of a constant relationship between complaints and the frequency of conflict, and could lead to inappropriate management actions if the reporting rate for human–bear interactions changes. Trends in population size are even sometimes inferred from trends in human–bear conflict. At the end of the 1980s, the number of North

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American jurisdictions that inferred black bear population trend from human–bear conflict data was second only to the number using harvest data to infer population trend (Garshelis 1991). A more recent study suggested that population declines would be apparent from trends in human–bear conflict, among other indicators (Garshelis and Hristienko 2006).

In the mid–1990s animal welfare organizations in Ontario lobbied to ban the spring black bear hunting season. In 1999, Ontario's spring bear season was cancelled (Ontario Regulation 88/99), although the fall season was extended because annual harvests were deemed sustainable. It also became mandatory for citizens who killed bears in defense of property to report doing so to the Ontario Ministry of Natural Resources (OMNR; Ontario Regulation 665/98, s. 130). The cancellation of the spring hunting season adversely affected the economies of several communities in black bear range (Poulin et al. 2003). Hunter and outfitter associations campaigned for the hunt's reinstatement on these grounds, but also held that the hunt cancellation would lead to increases in the bear population, in human–bear conflicts, and in risks to human safety (e.g., Quinney 2002, Canadian Outdoor Heritage Alliance 2004). Complaints and media coverage regarding black bears and conflicts with humans increased dramatically in 1999, 2000, and 2001 (Poulin et al. 2003). In 2002, in response to the controversy, the Minister of Natural Resources in Ontario appointed an independent committee to review the nuisance bear issue from biological and socioeconomic perspectives. That committee concluded that annual variation in the frequency of human–bear conflict was best explained by varying availability of natural foods, and that there was no evidence that the spring hunt cancellation caused the perceived increases in the bear population or in human–bear conflicts. However, for socioeconomic reasons, the committee recommended reinstating the hunt under strict conditions, such as a males-only harvest (Poulin et al. 2003). The spring hunting season was not reinstated; however, other recommendations from the review committee (Poulin et al. 2003) led the OMNR to develop a program to prevent, monitor, educate the public about, and respond to human–bear conflicts. The program, named "Bear Wise," was launched in April 2004, and included a 24-hour, toll-free telephone line for reporting human–bear conflicts (Obbard and Greenwood 2007, Ontario Ministry of Natural Resources 2008).

Our objective was to test whether the frequency of human–black bear conflict changed following the management regime changes of 1999 and 2004, while controlling for effects of those management regime changes on the reporting rate for human–bear interactions. In Ontario and elsewhere, the frequency of conflict increased when natural foods were scarce (Rogers et al. 1976, Poulin et al. 2003, Garshelis and Noyce 2008). Prior harvests could also be inversely related to the frequency of conflict if they reduced bear density or removed bears prone to conflict with humans from the population. We tested for effects of food availability, prior harvests, and management regime changes on numbers of complaints about conflicts with bears, traps set to capture bears involved in conflicts, and bears killed in defense of property in the Parry Sound administrative area (PSA) of the Ontario Ministry of Natural Resources.

The size, age, and sex composition of the bear population could also affect the frequency of human–bear conflict. We could not assess these directly because the age and sex composition of the population was unknown, and only limited data on population size were available. We present analyses of harvest metrics and population simulations as indicators of the effect of harvest on the size, age, and sex composition of the bear population.

Study area

Data were specific to OMNR's Parry Sound administrative area. PSA lies in the Great Lakes–St. Lawrence Forest Region (Rowe 1972) on the eastern shore of Georgian Bay in south-central Ontario, centered at 45°35′N, 80°0′W (Fig. 1). The length of the growing season ranged from 180–200 days between 1968 and 1988 (Watson and MacIver 1995). Most of PSA is forested and occupied by black bears. Black bear density was estimated in each of 3 Wildlife Management Units in PSA—1 in 2005, and 2 in 2006. Estimated densities were 0.30 (SE 0.08), 0.36 (SE 0.13), and 0.44 (SE 0.12) bears/km^2. Extrapolating these densities to the area of suitable habitat within each unit yielded a population estimate of 4,609 bears (SE = 1,383) in PSA (M.E. Obbard, unpublished data). Human population density (persons/km^2) ranged from 0.4 to less than 10 in most of PSA but exceeded 10 in developed areas and exceeded 49 in the municipality of Parry Sound (Statistics Canada 2007a). The human population of PSA was stable between 1991

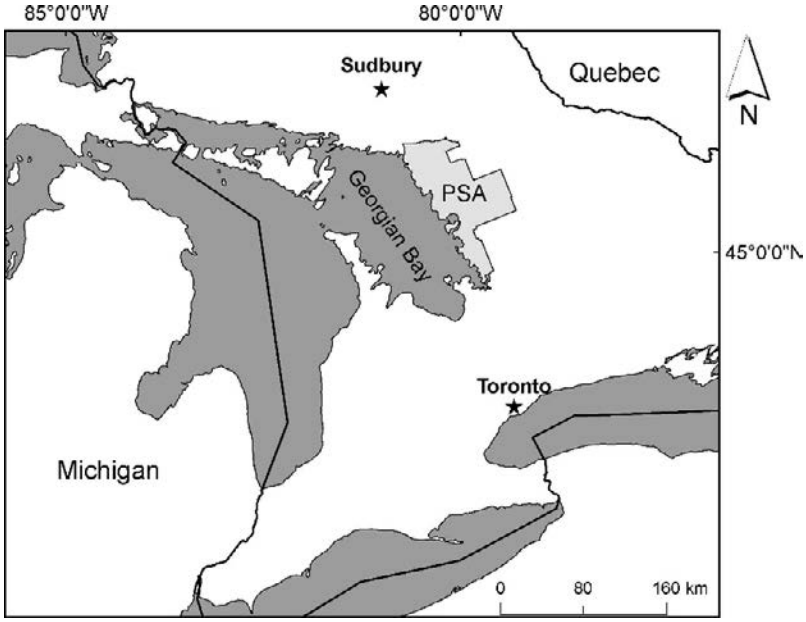

Fig. 1. Location of the study area (PSA; light grey) in south-central Ontario, Canada, including the Great Lakes (dark grey) and cities (stars). Heavy black lines are provincial and international borders.

and 1996 (Statistics Canada 2007b). It was stable or decreased (rate of change = −4% to 0%) between 1996 and 2001 except in the southern census division (approximately 15% of the total study area), where it increased by >4% (Statistics Canada 2002). Human population was stable or decreased between 2001 and 2006 (rate of change = −5% to 0%) except in the southern census division, where it increased by 5 to <10% (Statistics Canada 2007c).

Methods

We assessed natural food availability by ranking the productivity (in terms of fruit production) of the following species (or groups of species) used by black bears on a 5-point scale, where 0 indicated complete failure and 4 indicated a bumper crop: oaks (*Quercus* spp.), American beech (*Fagus grandifolia*), mountain ash (*Sorbus americana*, and *S. decora*), beaked hazel (*Corylus cornuta*), cherries (*Prunus* spp.), juneberry (*Amelanchier* spp.), blackberry (*Rubus* spp.), raspberry (*Rubus ideaus*), and blueberry (*Vaccinium angustifolium* and *V. myrtilloides*). Productivity was assessed at 17 sites annually during 1992–2002 and at 25 sites annually during 2003–08. To calculate an annual index of food availability, we calculated the mean of productivity scores for each species across sites, then across species. Records of public complaints to OMNR about human–bear conflicts were maintained locally at the Parry Sound Area office of the OMNR from 1992–2003, and in a provincial database after 2003. We analyzed 3 annual measures of human–bear conflict: (1) numbers of public complaints about human–bear conflict, (2) the number of times traps were set to capture bears involved in conflicts, and (3) numbers of bears killed in defense of property by OMNR staff, licensed agents, or private citizens. We natural log transformed human–bear conflict data prior to analysis because they were right-skewed. Because data for the number of traps set in a year included zero values, we increased the number of traps set in each year by one before applying the transformation. The OMNR compiled black bear harvest data at the Wildlife Management Unit scale; therefore, we summed harvests across units located completely or mostly within PSA to approximate harvests within PSA. Food availability data were not collected in 1993, so we excluded data from 1993 from all time series.

We expected that all measures of human–bear conflict would vary inversely with food availability. We hypothesized that complaints about conflicts would increase after 1998 via an increase in the reporting rate for human–bear interactions because of increased awareness of, and perceived risk from, bears, due to the controversy surrounding the cancellation of the spring bear hunt (CSH). We assumed that the number of traps set was insensitive to changes in the reporting rate for human–bear interactions because traps were set only when necessary to prevent further property damage or risks to human safety after investigation by OMNR staff. Although agency responses to complaints could vary with changing staff or directives, we are confident that, in our case, traps were only set when necessary because the third author was the District Biologist responsible for bear management in PSA for the duration of the study. Increases in the number of traps set after 1998 would therefore indicate that the actual frequency of conflict increased after the CSH. Reductions in the number of traps set or bears killed in defense of property after 2003 would indicate success of the Bear Wise program at reducing conflicts or increasing the public's tolerance for black bears. Inverse relationships between prior harvests and measures of human–bear conflict would indicate that higher harvests reduced subsequent conflict.

Prior to performing regressions to test for effects on measures of human–bear conflict and harvest metrics, we calculated Pearson's correlation coefficients among all variables describing human–bear conflict, harvest, food, and management regime changes. We used correlation coefficients to determine if the direction of associations were consistent with the hypothesized effects described above and to check for collinearity among potential predictor variables in the regression analyses.

Potential continuous predictors of measures of human–bear conflict were food availability, the number of bears harvested in the previous year ($harv_{-1}$), the sum of bears harvested in fall of year t-1 and in spring of year t ($harv_{-SF}$), and the average number of bears harvested across the previous 3 years ($avharv_{-3}$). The cancellation of the spring hunting season and the launch of the Bear Wise program (BW) were modeled as logical predictors, where CSH was set to 0 from 1992–1998 and to 1 after 1998, and BW was set to 0 from 1992–2003 and to 1 after 2003. Support for predictors was assessed by fitting linear regression models with all additive combinations of predictor variables on each measure of human–bear conflict, comparing models fit to the same data using Akaike's Information Criterion adjusted for small sample size (AIC_c; Hurvitch and Tsai 1989) and calculating the sum of AIC_c weights (Σw_i) across models including each effect. We inferred support for predictors across candidate model sets when Σw_i was greater than the proportion of models including the effect (Anderson 2008).

To assess how the CSH and annual variation in harvests may have affected the size, age, and sex composition of the bear population, we used linear regression to test for effects of food availability, the CSH, $avharv_{-3}$, and total annual harvest (*anharv*) on proportions of females and adult females in the harvest (% F and % ad F, respectively), and for effects of food availability, the number of hunters, and the CSH on the total annual harvest. We evaluated predictors of harvest metrics using the sum of AIC_c weights across models including each predictor, as we did for measures of human–bear conflict.

We simulated the bear population in PSA using the RISKMAN population model (version 1.9.003; Taylor et al. 2006) to estimate the trend in the bear population during the study. We parameterized the model with reproductive rate and cub survival estimates from Kolenosky (1990) and with natural survival estimates of other age classes from Obbard and Howe (2008); standard errors around all vital rates were included in stochastic simulations. Survival and reproductive rates were estimated from data from hunted populations (Kolenosky 1990, Obbard and Howe 2008) and we simulated the population for only 5 years, so we did not model additional effects of bear density on demographic rates. We used the population estimate of 4,609 (SE = 1,383) as the initial population in simulations. Simulated populations were subject to a selective (on males) harvest of 289 (SE 35) bears annually (the mean annual harvest over the duration of the study). We varied the number of additional bears killed (e.g., by vehicles or in defense of property) because actual numbers were unknown. Data to apply the methods of Cherry et al. (2002) to estimate the number of unreported mortalities were not available. The reported number of bears killed by humans, excluding legal harvests, averaged 19 since the institution of mandatory reporting for bears killed in defense of property in 1999. We set the number of bears killed annually by humans, in addition to those harvested, to 20, 30, and 40 bears annually because we suspected there were nearly as many unreported as reported mortalities. One thousand iterations of the model were performed at each value of addi-

Table 1. Pearson correlation coefficients between pairs of variables describing food availability, management regime changes, human–bear conflict, and harvest of black bears in Parry Sound Area, Ontario, Canada, annually, 1992–2008. Variables were food availability, cancellation of the spring hunt (CSH), presence of the Bear Wise program (BW), traps set to capture bears involved in conflicts, bears killed in defense of property, complaints to management agency about human–bear conflict, mean annual harvest for the previous 3 years (*$avharv_{-3}$*), total harvest the previous year (*$harv_{-1}$*), total harvest in fall of year *t*-1 and spring of year *t* (*$harv_{-SF}$*), total annual harvest (*anharv*), the number of bear hunters, % females harvested, and % adult females harvested. Data for complaints, traps set, and bears killed were natural log transformed before calculating coefficients; the number of traps set was increased by one before applying the transformation.

	Food	CSH	BW	Traps	Killed	Complaints	$avharv_{-3}$	$harv_{-1}$	$harv_{-SF}$	*anharv*	Hunters	% F	% ad F
Food	1.00	−0.31	0.01	−0.51	−0.39	−0.60	−0.25	−0.58	−0.63	0.35	−0.17	−0.60	−0.18
CSH		1.00	0.52	0.12	0.33	0.75	0.55	0.18	0.13	0.38	0.66	0.21	0.33
BW			1.00	0.09	−0.01	0.47	0.55	0.14	0.10	0.24	0.32	−0.11	0.54
Traps				1.00	0.60	0.53	−0.13	0.18	0.24	−0.11	−0.20	0.54	−0.18
Killed					1.00	0.49	0.19	0.18	0.06	−0.10	0.37	0.23	0.00
Complaints						1.00	0.52	0.55	0.54	0.20	0.56	0.40	0.40
$avharv_{-3}$							1.00	0.55	0.45	0.13	0.69	−0.08	0.53
$harv_{-1}$								1.00	0.97	−0.17	0.39	0.24	0.24
$harv_{-SF}$									1.00	−0.17	0.29	0.33	0.25
anharv										1.00	0.32	0.19	0.16
Hunters											1.00	0.08	0.67
% F												1.00	0.06
% ad F													1.00

tional mortality with all other parameters held constant.

Results

Correlations

Pearson's correlation coefficients between food availability and all measures of human–bear conflict were negative, but the one between food availability and the total annual harvest was positive (Table 1). Correlating complaints with each of $harv_{-SF}$, $harv_{-1}$, and $avharv_{-3}$ yielded positive coefficients (Table 1). Correlation coefficients between previous harvests and both the number of traps set and the number of bears killed suggested positive associations, if any, and the correlation coefficient between $avharv_{-3}$ and the number of traps set suggested a negative association, if any (Table 1).

Human–bear conflict

Generally, measures of human–bear conflict were high following years and spring seasons with higher harvests (Table 1). These relationships seemed unlikely to be causal, so we did not include harvest variables among potential predictors of measures of conflict. We therefore fit 8 models with all additive combinations of effects of food availability, the CSH, and BW on measures of human–bear conflict. Both food availability and the spring hunt cancellation affected the number of complaints to OMNR (Table 2). There were more complaints after the CSH ($\beta = 1.12$, SE = 0.31) and in years of low food availability ($\beta = -0.52$, SE = 0.20). The model with food availability as the only predictor ranked first among models fit to data for traps set to capture bears involved in conflicts and bears killed in defense of property. There was a tendency for more traps to

Table 2. Top AIC$_c$-ranked models and their probabilities (left, w_i), and sums of model probabilities across all models (right) that included effects of food availability and the management regime changes of 1999 (CSH) and 2004 (BW) on measures of human–bear conflict in Parry Sound Area, Ontario, Canada, 1992–2008. Support for predictors was inferred where $\Sigma w_i > 0.5$.

			Σw_i for individual effects		
Dependent variable	Model	w_i	Food	CSH	BW
Complaints	Food + CSH	0.61	0.849	0.955	0.254
Traps set	Food	0.46	0.586	0.104	0.107
Bears killed	Food	0.39	0.502	0.270	0.149

Table 3. Top AIC$_c$-ranked models, their probabilities (left, w_i), and sums of model probabilities across all models (right) that included effects of food availability, the management regime change of 1999 (CSH), the mean annual harvest across the previous 3 years (*avharv*$_{-3}$) and total harvest in the same year (*anharv*) on proportions of females and adult females in the harvest in Parry Sound Area, Ontario, Canada, 1992–2008. Support for predictors was inferred where $\Sigma w_i > 0.5$.

			Σw_i for individual effects			
Dependent variables	Model	w_i	Food	CSH	*avharv*$_{-3}$	*anharv*
% female	food + *anharv*	0.39	0.97	0.16	0.47	0.79
% adult female	*avharv*$_{-3}$	0.42	0.15	0.20	0.65	0.16

be set and more bears to be killed in years of low food availability ($\beta = -0.71$, SE = 0.32 and $\beta = -0.51$, SE = 0.32, respectively); however, in both cases the null model ranked second with similar support (ΔAIC$_c$ = 0.58 and 1.04, respectively), and Σw_i for the effect of food availability was close to 0.5 (Table 2). Because AIC$_c$ values and weights yielded somewhat ambiguous results regarding the effect of food availability on numbers of traps set and bears killed, we performed *t*-tests of the significance of the regression coefficients from models with food as the only predictor of the number of each of traps set and bears killed. The effect of food availability on the number of traps set was significant ($t = -2.24$, 14 df, $P = 0.04$), but its effect on the number of bears killed was not ($t = -1.58$, 14 df, $P = 0.13$). The Bear Wise program had no detectable effect on human–bear conflict (Table 2).

Harvest

Food availability and total annual harvest were associated with the proportion of females in the harvest (Table 3); however, support for the model with both predictors may have been partially attributable to collinearity between them (Zar 1999; Table 1). The model with food as the only predictor of the proportion of females in the harvest ranked second, with similar AIC$_c$ support as the top model (ΔAIC$_c$ = 1.69), and more AIC$_c$ support than the null model. But the model with total harvest as the only predictor ranked 11th, with less support than the null model, so an independent association between total annual harvest and the proportion of females in the harvest was not supported (ΔAIC$_c$ values for the null model and the model with total harvest as the only predictor relative to the top model were 5.62 and 8.10, respectively). A greater proportion of females were harvested when food availability was lower ($\beta = -2.54$, SE = 0.92, from the model with food as the only predictor). The proportion of adult females in the harvest was insensitive to food availability but increased when the 3-year average of previous harvests was high (Table 3; $\beta = 0.12$, SE = 0.05). The CSH did not affect proportions of females or adult females in the harvest (Table 3).

Food availability and the total annual harvest were positively related (Table 1). We felt this was unlikely to be a causal relationship (Noyce and Garshelis 1997), so we excluded data on food availability from regressions testing for effects on total harvest. The null model ranked highest of the 4 models fit to data with total annual harvest as the dependent variable. Neither the CSH ($\Sigma w_i = 0.37$) nor the number of hunters ($\Sigma w_i = 0.27$) were important predictors of total annual harvest.

Population simulations

The average growth rate of simulated populations was slightly positive regardless of the number of bears killed annually by humans in addition to those legally harvested, but a stable or declining population was also possible within the range of uncertainty in stochastic simulations (Table 4).

Table 4. Geometric mean population growth rate (λ) and the median and 95% confidence interval (CI) of population size, after 5 years, across 1,000 iterations of the RISKMAN population model parameterized to simulate the population of black bears in Parry Sound Area, Ontario, Canada, 1992–2008.

Bears killed by humans annually in addition to legal harvests	Geometric mean, λ	Median population	95% CI
20	1.026	5,216	3,555–7,263
30	1.022	5,190	3,503–7,177
40	1.017	5,055	3,312–6,953

Discussion

There are several possible explanations for the increase in the number of complaints about human–bear conflict following the cancellation of the spring hunting season. An increase in the bear population due to reduced harvest was purported by hunters and tourist operators. Our simulations suggest the bear population in PSA may have been slowly increasing over the time examined, but a stable or slowly declining population was also possible. Our correlation and regression analyses showed that the management regime change did not alter the effect of harvest on the bear population, nor did higher harvests reduce subsequent conflict. For example, the total annual harvest did not decrease after the CSH, so lack of an effect of spring harvests on population size was compensated for by higher harvests in the previous fall, 1999 being an exception. Proportions of females and adult females in the harvest were also unaffected by the spring season closure, so higher proportions of the potentially more conflict-prone male segment of the population (Rogers et al. 1976, Garshelis 1989) were not removed by harvest when there was a spring season. Finally, associations between prior harvests and measures of human–bear conflict were positive, so removing more bears did not reduce subsequent conflict. Similarly, Treves et al. (2010) did not detect an inverse relationship between total harvest and subsequent human–bear conflict in Wisconsin. They recommended a cautious interpretation of this result and commented that the observed positive correlation between total harvest and subsequent conflict may have been attributable to increases in bear population size, harvest, and nuisance complaints observed in part of their study area.

Baiting was the most popular method of bear hunting in Ontario before and since the CSH (de Almeida and Obbard 2002, 2005). The CSH therefore likely reduced the amount of supplemental food available to bears in the spring, so could have caused an increase in human–bear conflict independent of an effect of harvest on population size or age–sex distribution, through an effect on nutritional stress. Baits maintained by hunters and outfitters provided supplemental food for bears in Virginia, though use of feeding sites may have been compensatory rather than additive (Gray et al. 2004). In Minnesota, most bears stopped visiting diversionary feeding sites when natural foods became available, even in a year with very low availability of natural foods (Rogers in press). Supplemental feeding during spring and early summer reduced bear damage of conifers in Washington (Ziegltrum 2004); however, bears achieved the same weights after feeding stopped and natural foods became available in summer whether or not they had access to supplemental food in spring (Partridge et al. 2001). Spring feeding may therefore have little or no effect on nutritional stress of bears or on human–bear conflict later in the active season. In PSA, human–bear conflict was lower and less variable among years in spring and early summer than in mid-summer and autumn (Landriault 1998, Poulin et al. 2003, L. Wall, Ontario Ministry of Natural Resources, South Porcupine, Ontario, Canada, unpublished data), so an effect of the CSH on human–bear conflict occurring in the spring might not have a detectable effect on annual measures of human–bear conflict, as we tested for.

We suggest that a change in the reporting rate for human–bear interactions is a more plausible explanation for the increase in complaints after 1998, because if the actual frequency or severity of human–bear conflict had increased, so would the number of traps set to capture bears involved in conflicts. The reporting rate could have increased due to increased awareness and perception of risk from bears, or to reduced tolerance for them (i.e., reduced social carrying capacity). Residents of Ontario may have accepted the explanation proposed by opponents of the cancellation of the spring hunt and often quoted or repeated in the media: that both the bear population and the probability of dangerous encounters would increase after the CSH.

Alternatively, perceived risk may have increased because the cancellation of the spring season and failure to reinstate it despite disapproval of these decisions by some Ontarians generated a lack of trust in the OMNR's willingness or ability to manage bears to prevent conflict. For example, trust in the managing agency and its ability to respond to human–black bear conflicts affected the perceived risk from human–black bear conflicts in New York's Adirondack Park (Gore et al. 2006b). If individuals perceived that they or their property were at greater risk from bears, they may have been more likely to report conflicts to the OMNR when they encountered bears near their homes or developed areas. Furthermore, if residents of PSA believed that the presence or absence of a spring hunt was the main factor affecting the risk of human–bear conflict, they may have attempted to reduce their risk from bears by calling for a reinstatement of the spring hunt rather than by modifying their behavior to reduce risk (e.g., by removing attractants from their property).

Multifaceted approaches to preventing and reducing human–bear conflict, including education and outreach initiatives, are now the norm across Canada and the United States (Spencer et al. 2007), but evaluations of the effectiveness of such initiatives are lacking (Ferraro and Pattanayak 2006, Spencer et al. 2007), and a reduction in complaints should not be the only measure of their success (Treves and Karanth 2003, Gore et al. 2006a). We did not detect an effect of the Bear Wise Program on any measure of human–bear conflict. Similarly, other education and outreach programs had variable success at improving the public's understanding of how to avoid human–bear conflict (Dunn et al. 2008, Gore et al. 2008) and did not result in more responsible behavior on the part of the target audience in the short-term (Gore et al. 2008). The relatively short time since the launch of the Bear Wise program may explain why we detected no effect on measures of human–bear conflict in PSA to 2008. Limited research to date suggests that to change attitudes and increase environmentally responsible behavior, education programs must convey their message repeatedly over extended periods of time (Blanchard 1995, Weber 1995, Engels and Jacobson 2007). We agree with Gore et al. (2008) that evaluations of the effectiveness of education and outreach initiatives at reducing human–bear conflict should be conducted over longer periods of time.

That the annual variation in total harvest and the number of bears killed in defense of property were not well explained by our predictors, and that correlation coefficients between complaints and both $harv_{-SF}$ and $harv_{-1}$, and between food availability and total harvest in the same year were positive warrants further discussion. We may have failed to identify significant predictors of the number of bears killed in defense of property annually because many of them were not reported to OMNR despite the legal requirement to do so. However, we also hypothesize that food failures synchronized reproduction in PSA, that large year-classes can account for some of the unexplained variation in total harvest and possibly in measures of human–bear conflict, and that a combination of reproductive synchrony and an approximately biennial pattern of food availability across much of our time series could explain the positive correlation between measures of human–bear conflict and prior harvests and between food availability and total annual harvests. Food failures frequently synchronize reproduction in black bear populations (McLaughlin et al. 1994, Costello et al. 2003, Clark et al. 2005, Obbard and Howe 2008); large cohorts of cubs produced 2 years after food failures are first apparent in subsequent harvest age distribution data as yearlings (Konito et al. 1998, Costello et al. 2001, Bridges 2005, Garshelis and Noyce 2008). In our study, food availability scores in odd-numbered years were all lower than the median and were lowest in 1995, 1997, 2001, and 2007. Given biennial fluctuations in food availability and the negative effect of food availability on conflicts, we would expect elevated levels of conflict 2, 4, etc. years after food failures. However, the effect of food failures on reproduction would make large cohorts of yearlings available for harvest (and possibly to come into conflict with humans) 3, 5, etc. years after food failures. If the availability of many yearlings led to higher harvests, high harvests would coincide with years of good food availability and would be followed by years with more conflicts because good food years were usually followed by poor food years (and associated elevated human–bear conflict) in our time series. Total harvest peaked in PSA in 1996, 2000, 2002, and 2004; food availability 3 years previous was unknown, failure, low, and failure, respectively.

Management implications

Wildlife biologists and managers should carefully evaluate whether trends in numbers of public complaints about human–bear conflict reflect the actual frequency or severity of human–bear conflict before drawing inferences from, or making management decisions based on, trends in complaint data. Our data suggest that controversy or public dissatisfaction regarding management regime changes can affect the reporting rate for human–bear interactions and so alter the relationship between complaint data and the actual frequency of conflicts. Our results are consistent with those of Treves and Karanth (2003), who found that liberal hunting regimes contributed to high public tolerance for large carnivores but did not reduce human–carnivore conflicts. Our results also suggest an alternate explanation for the patterns in survey data presented by Hristienko and McDonald (2007). Most management agencies use complaint data to infer trends in human–bear conflict (Spencer et al. 2007). Hristienko and McDonald (2007) found that management agencies characterized conflict levels as stable in jurisdictions with liberal hunting regimes, but as increasing where hunting regimes were restrictive. They inferred that harvesting, particularly in spring, reduced human–bear conflict through effects on bear distribution and density. In our study, cancellation of the spring hunt was associated with a dramatic increase in complaints even though annual harvests remained stable or increased, and there was no effect of the CSH on numbers of traps set to capture bears involved in conflicts or bears killed in defense of property. Harvesting could reduce the actual frequency and severity of human–bear conflict through an effect on bear distribution and density (though data on this are often contradictory). However, the relationship between harvest regimes and trends in human–bear conflict observed by Hristienko and McDonald (2007) could also reflect an effect of liberal harvest regimes on social carrying capacity. Our data support the latter mechanism.

Hristienko and McDonald (2007:80) stated "With fewer bears, it is natural to assume that there would be fewer human–bear interactions resulting in fewer complaints"; this may be so, though the authors present no data to support this assertion. We could not test this assumption directly because information on bear population trend was not available. However, prior harvests and any effect they had on bear density within the range of harvests observed did not reduce subsequent human–bear conflict in our study area. We are aware of only one data set that demonstrated a relationship between bear population size and the frequency of human–bear conflict, in Minnesota, where the bear population tripled over 15 years (Garshelis and Noyce 2008). Even then, the effect was only apparent in years of low food availability (Garshelis and Noyce 2008). Miller (1990) argued that increases in human–bear conflict more commonly correspond to declining rather than increasing bear populations because human–bear conflict reflects human use of bear habitat more than bear population size.

We caution against assuming a continuous relationship between bear density and human–bear conflict in the absence of supporting data. In contrast, the effect of food availability on American black bears at a wide range of densities is well-established. When natural foods are scarce, black bears are more prone to anthropogenic mortality and conflict with humans as they range farther and aggressively seek out anthropogenic foods (Schorger 1946; Rogers 1987; Garshelis 1989; Noyce and Garshelis 1997; Garshelis and Noyce 2001; Ryan et al. 2004, 2007). The availability of foods preferred by black bears is highly variable among years (Noyce and Coy 1990, Sork et al. 1993). In our study, 6 of 16 years were characterized by low food availability and elevated human–bear conflict. Similarly, combined food production by members of the 3 plant genera deemed most important to bears in New Mexico failed in 7 of 15 years (Costello et al. 2003). Elsewhere, food failures were observed at approximately 5-year intervals and were associated with high levels of human–bear conflict (Ryan et al. 2007, Garshelis and Noyce 2008). Managing bear density alone is therefore unlikely to prevent frequently elevated levels of human–bear conflict except where bears are maintained at very low densities or are effectively removed from the landscape outside protected areas—a management scheme that is at odds with one of human–carnivore coexistence.

Maintaining low bear densities outside protected areas could reduce human–bear conflict but may interfere with the objective of providing bear hunting opportunities. Sustainable yield from a black bear population is likely maximal slightly below carrying capacity (Fowler 1981). The existence of density-compensatory increases in growth rates of hunted black bear populations remains controversial; however, recent studies in Alberta and Ontario provided evidence of increased reproduction by young females at lower density (Czetwertynski et al. 2007, Obbard and Howe 2008). If such a response is universal in black bear populations, then increasing harvest rates may lead to increased population growth. Nevertheless, if population size is greatly reduced in an attempt to reduce human–bear conflict, subsequent harvests would need to be reduced to stabilize populations at the desired density and prevent further declines or local extirpations. Optimal black bear management will likely be achieved through integrated approaches that manage both bear populations (i.e., by harvesting) and human behavior (i.e., through education and outreach).

Where bear populations are productive and reserves protect large, viable populations, a large portion of the unprotected population might be removed annually without compromising population viability, though a thorough understanding of source–sink dynamics in bear populations is lacking. Nevertheless, in such areas, a functional inverse relationship between harvest and human–bear conflict might be achievable. Elsewhere, the limiting effect of habitat quality on population growth precludes removing a large portion of the bear population each year (Kolenosky 1986, Rogers 1993, Costello et al. 2001), so the effect that a sustained harvest can have on human–bear conflict is limited. We suggest that habitat in most Canadian and many US jurisdictions may not be sufficiently productive to allow a large enough portion of the bear population to be removed annually to significantly reduce the frequency of human–bear conflict. In our study, harvests removed approximately 7% and other anthropogenic mortality approximately 1% of the standing population in PSA annually. Simulation results and the increased proportion of adult females in the harvest following 3 years with high harvests suggest this rate of anthropogenic mortality was near the maximum sustainable. Habitats providing abundant hard and soft mast were relatively common in PSA. Lower productivity of black bear habitat in boreal forests and xeric environments in the American southwest could translate into similar or lower sustainable harvest rates across much of black bear range (Costello et al. 2001, Obbard and Howe 2008). In such habitats, management actions that target human behavior are likely to be of greater importance among components of an integrated approach to the management of human–bear conflict.

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