2020

Psychological drivers of risk-reducing behaviors to limit human–wildlife conflict

Stacy A. Lischka
Colorado Parks and Wildlife, stacy@csp-inc.org

Tara L. Teel
Colorado State University - Fort Collins, tteel@lamar.colostate.edu

Heather E. Johnson
Colorado Parks and Wildlife, heatherjohnson@usgs.gov

Courtney Larson
Colorado State University, courtney.larson@colostate.edu

Stewart Breck
USDA-ARS NWRC, Stewart.W.Breck@usda.gov

Conservation Biology

Special Section Contributed Paper

Psychological drivers of risk-reducing behaviors to limit human–wildlife conflict

Stacy A. Lischka [1,2] * Tara L. Teel [3] Heather E. Johnson [4] † Courtney Larson [2] Stewart Breck,[5] and Kevin Crooks[2]

[1]Research, Policy, and Planning Branch, Colorado Parks and Wildlife, 317 W. Prospect Ave., Fort Collins, CO, 80526, U.S.A.
[2]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO, 80523, U.S.A.
[3]Department of Human Dimensions of Natural Resources, Colorado State University, Fort Collins, CO, 80523, U.S.A.
[4]Research, Policy, and Planning Branch, Colorado Parks and Wildlife, 415 Turner Dr., Durango, CO, 81301, U.S.A.
[5]National Wildlife Research Center, USDA Wildlife Services, 4101 Laporte Ave., Fort Collins, CO, 80521, U.S.A.

Abstract: Conflicts between people and wild animals are increasing globally, often with serious consequences for both. Local regulations or ordinances are frequently used to promote human behaviors that minimize these conflicts (risk-reducing behaviors), but compliance with ordinances can be highly variable. While efforts to increase compliance could be improved through applications of conservation psychology, little is known about the relative influence of different factors motivating compliance. Using concepts from psychology and risk theory, we conducted a longitudinal study pairing data from mail surveys with direct observations of compliance with a wildlife ordinance requiring residents to secure residential garbage from black bears (*Ursus americanus*). We assessed the relative influence of beliefs and attitudes toward bears and bear proofing, perceived behavioral control, perceived risks and benefits assigned to bears, norms, trust in management, previous experience with conflicts, and demographics on compliance behavior (i.e., bear proofing). Data on previous experience were obtained through direct observation and survey reports. We found that higher compliance rates were associated with more observed conflicts on a respondent's block. Counter to expectations, however, residents were less compliant when they were more trusting of the management agency and perceived more benefits from bears. We suggest that messages have the potential to increase compliance when they empower residents by linking successful management of conflicts to individual actions and emphasize how reducing conflicts could maintain benefits provided by wildlife. Modifying existing educational materials to account for these psychological considerations and evaluating their impact on compliance behavior over time are important next steps in changing human behaviors relevant to the globally important problem of human-wildlife conflict.

Keywords: black bears, compliance, behavior change, pro-environmental behavior, Colorado, human–black bear conflict

Impulsores Psicológicos de los Comportamientos Reductores de Riesgo para Limitar el Conflicto Humano - Fauna

Resumen: Los conflictos entre las personas y la fauna cada vez son más a nivel mundial y con frecuencia tienen consecuencias severas para ambos. Las regulaciones o decretos locales se usan frecuentemente para promover comportamientos humanos que minimizan estos conflictos (comportamientos reductores de riesgo), pero el cumplimiento de los decretos puede ser altamente variable. Mientras que los esfuerzos por incrementar el cumplimiento podrían mejorar por medio de la aplicación de la psicología de la conservación, se conoce poco sobre la influencia relativa de los diferentes factores que motivan al cumplimiento. Realizamos un estudio longitudinal mediante conceptos tomados de la psicología y la teoría del riesgo. Este estudio emparejó datos obtenidos de encuestas por correo con observaciones directas del cumplimiento de un decreto de fauna que

*Current address: Research, Policy, and Planning Branch, Colorado Parks and Wildlife, 317 W. Prospect Ave., Fort Collins, CO 80526, U.S.A., email stacy@csp-inc.org
†Current address: U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, AK 99508, U.S.A.
***Article Impact Statement**: Compliance with wildlife ordinances may increase if conflict reduction links to individual action and maintenance of benefits from wildlife.*
Paper submitted November 12, 2019; revised manuscript accepted June 19, 2020.

Conservation Biology, Volume 34, No. 6, 1383–1392

DOI: 10.1111/cobi.13626

requiere que los residentes protejan los desechos residenciales de los osos negros (*Ursus americanus*) (es decir, hacerlas a prueba de osos). Evaluamos la influencia relativa de las creencias y las actitudes hacia los osos y hacia hacer los desechos a prueba de osos, el control del comportamiento percibido, los riesgos percibidos y los beneficios asignados a los osos, las normas, la confianza en el manejo, la experiencia previa con conflictos y la demografía del comportamiento de cumplimiento. Los datos sobre la experiencia previa se obtuvieron mediante observación directa y reportes de las encuestas. Encontramos que las tasas más altas de cumplimiento estuvieron asociadas con un mayor número de conflictos observados en la cuadra del respondiente. Sin embargo, contrario a las expectativas, los residentes fueron menos obedientes cuando tuvieron mayor confianza en la agencia de manejo y percibieron más beneficios de la presencia de osos. Sugerimos que los mensajes tienen el potencial de incrementar el cumplimiento cuando empoderan a los residentes al vincular el manejo exitoso de los conflictos con las acciones individuales y enfatizan cómo la reducción de los conflictos podría mantener los beneficios que proporciona la fauna. La modificación de los materiales educativos existentes para que tomen en cuenta estas consideraciones psicológicas y la evaluación de su impacto sobre el comportamiento de cumplimiento a lo largo del tiempo son los siguientes pasos importantes para modificar el comportamiento humano relevante para el problema mundialmente importante que es el conflicto humano - fauna.

摘要: 全球范围内, 人类与野生动物的冲突正在不断加剧, 并经常给二者都带来严重的后果。有许多地方法规或条例旨在改变人类行为来最大程度地减缓冲突 (降低风险的行为), 但是人们对这些条例的服从情况可能是复杂多样的。虽然可以应用保护心理学来提高人们对条例的服从, 但我们对激励服从的不同因素的相对影响仍知之甚少。我们利用心理学和风险理论的概念进行了一项纵向研究, 将来自邮件调查的数据与直接观察到的对一项要求居民避免住宅垃圾被黑熊 (*Ursus americanus*) 吃掉的野生动物条例 (即防熊条例) 的遵守性数据进行了配对。我们评估了对黑熊和黑熊防御的信念与态度、感知到的行为控制、感知到的黑熊带来的风险与利益、规范、对管理的信任、以往的冲突经历以及人口统计数据对依从性的相对影响。以往经历的数据是通过直接观察和调查报告获得的。我们发现, 较高的服从率与受访者所在街区被观察到的较高冲突率有关。然而, 与预期相反的是, 当居民们更信任管理机构且从黑熊身上获得更多好处时, 他们的服从性会降低。我们建议, 如果将冲突的成功管理与个人行为相联系, 并强调减少冲突如何帮助维持野生动物带来的利益, 那么这些信息可能有利于增强居民的服从性。在现有教育材料的改编中考虑这些心理因素, 并评估它们在一段时间内对服从行为的影响, 是改变与人兽冲突这一全球重要问题有关的人类行为的重要步骤。**【翻译: 胡怡思; 审校 :聂永刚 】**

关键词: 黑熊, 服从性, 行为改变, 环保行为, 科罗拉多, 人类与黑熊的冲突

Introduction

Conflicts between people and wildlife are increasing globally due to accelerating human development (Woodroffe et al. 2005), range expansions of human-adapted species (Ripple et al. 2014), and species recovery (Chapron et al. 2014). Human–wildlife conflicts result from a juxtaposition of human and animal behaviors that can have direct impacts on both people (e.g., safety, property damage, livelihoods) and wildlife (e.g., disturbance, mortality, population reduction). Most technical solutions to these conflicts (e.g., altering livestock grazing practices, securing anthropogenic food) require human action to be successful (Nyhus 2016). Local regulations or ordinances can be an effective way to promote risk-reducing human behaviors to prevent and mitigate conflicts (Keane et al. 2008), but rates of compliance with ordinances vary. Conservation practitioners often draw on 2 approaches to induce compliance: enforcement actions, such as fines for noncompliance, and educational materials, such as signs or flyers, that instruct on desired behaviors (Keane et al. 2008). While enforcement can increase compliance, it is expensive to implement, may cause only short-term behavior changes, and can erode intrinsic motivation and trust in management authorities (Keane et al. 2008). Education efforts are often preferred as a less-intrusive alternative (e.g., Marley et al. 2017); however, there is considerable evidence indicating that provision of information alone rarely leads to behavior change, if not tailored to the specific audience and context (Schultz 2011).

Applying concepts from psychology could improve efforts aimed at promoting risk-reducing behaviors to address human–wildlife conflicts (Nilsson et al. 2019). In particular, attitude theory can provide guidance by identifying factors affecting these behaviors (Fig. 1, attitudinal factors). Defined as directional evaluations of a specific object or event (Eagly & Chaiken 1993), attitudes are one of the most frequently employed concepts for understanding conservation-related behaviors (St. John et al. 2010). When considered alone, however, their ability to explain behaviors is limited. Including other concepts, such as beliefs about the outcomes of a behavior (perceived effectiveness) and perceived ability to perform the behavior (perceived behavioral control), can improve understanding (Fishbein & Ajzen 2010). Further, easily accessible (i.e., salient) and context-specific attitudes, such as tolerance for a conflict-involved species, predict behaviors more strongly than general attitudes toward

conservation and less familiar objects (Fishbein & Ajzen 2010).

Risk communication theory also identifies a suite of psychological influences that have proven useful for understanding conservation-related behaviors, including in human–wildlife conflict situations (Kahler et al. 2013) (Fig. 1, risk-based factors). Risk perceptions, defined as assessments of the likelihood of an event and the magnitude of negative consequences resulting from it (Slovic 1987), are driven by familiarity with risk and dread associated with outcomes (Gore et al. 2009). Direct experience with conflicts can also affect perceived risks associated with species and their management (Gore et al. 2009). Relevant examples have linked risk perceptions to poaching behavior (Kahler & Gore 2012), willingness to report human–wildlife conflicts to authorities (Hayman et al. 2014), and participation in wildlife disease management initiatives (Triezenberg et al. 2014). Risk-based communications are commonly applied in behavior-change efforts, yet evaluations of the effectiveness of these efforts in conservation contexts are lacking (Gore et al. 2009).

Although attitude and risk concepts are frequently used to understand and encourage conservation-related behaviors, they assume individual behavior to be the result of reasoned choices guided by recognized, cognitive influences. These internal cognitive pathways make up only part of the decision-making process in humans. Decisions are also driven by the effects of broader factors including group and institutional influences (Lischka et al. 2018) (Fig. 1, broader factors). Norms, for example, are defined as informal codes and beliefs that define expected behaviors (Farrow et al. 2017). They are often shared by members of a social group and can be strong motivators or barriers to individual behavior (Schultz 2011). Though relatively underexplored in conservation contexts (St. John et al. 2010), norms have been shown to explain behaviors such as littering (Cialdini et al. 1991), retaliatory killing of predators (St. John et al. 2015), and commercial fish harvest (Gezelius 2002). Institutional factors include, for instance, policies guiding conflict management strategies (e.g., lethal removal of wildlife) and community relationships with and trust in management authorities. Trust has been linked to behaviors such as conflict reporting (Wilbur et al. 2018) and participation in recreational harvest (Rudolph & Riley 2014). By accounting for this broader array of influences emphasized in emergent behavior-change approahes such as community-based social marketing, practitioners could develop more effective messages for promoting conservation behaviors than knowledge-based appeals alone (McKenzie-Mohr 2011; Ardoin et al. 2013).

Building on this body of work, we sought to better understand the relative influence of psychological factors on risk-reducing behaviors, specifically in relation to compliance with local ordinances for addressing human–wildlife conflicts (Fig. 1). We modeled human behavior through a longitudinal study of human–black bear (*Ursus americanus*) conflicts in Colorado (U.S.A.). This case study provides a context in which conflicts can be highly contentious and have serious consequences for people and bears and risk-reducing human behaviors are effective at altering conflict rates (Johnson et al. 2018). Human–black bear conflicts are increasing across the United States (Hristienko & McDonald 2007), as bears learn to forage on anthropogenic foods, especially garbage (Lewis et al. 2015). At the same time, black bears are highly valued by urban and rural residents alike (Don Carlos et al. 2009; Morzillo et al. 2010). The outcomes of conflicts for people can range in severity from the inconvenience of having to pick up garbage strewn by bears to serious injury from bear attacks. For bears foraging in areas of human development can lead to increased human-caused injury, mortality, and even population declines (Laufenberg et al. 2018; Johnson et al. 2020). Expanding human development and climate-related natural food shortages are expected to exacerbate human–black bear interactions in the future (Laufenberg et al. 2018), which will likely continue to fuel social conflict over bear management (Don Carlos et al. 2009). These circumstances make human–bear conflicts an excellent model for understanding factors driving human-wildlife conflict in general, especially in settings where human development is influential (Nyhus 2016).

To reduce human–black bear conflicts, many communities throughout North America require residents to keep trash secured by municipal regulations, or ordinances, but compliance with these ordinances varies (Johnson et al. 2018). To understand residents' use

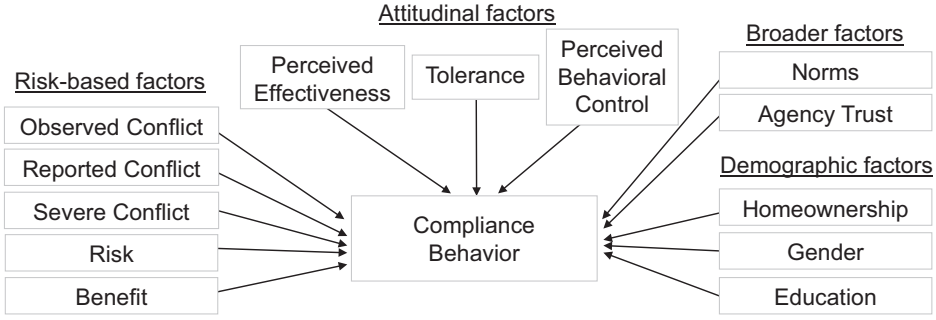

Figure 1. Factors predicted from theory and empirical evidence to have an influence on compliance with wildlife ordinances. Factors are grouped by conceptual alignment. We tested the effect of these factors on bear-proofing behavior in Colorado, United States.

of bear-resistant garbage containers (i.e., bear proofing), we paired direct observations of compliance and garbage-related conflicts with responses to mail surveys. Specifically, we tested the relative influence of attitudinal (i.e., tolerance for bears, perceived behavioral control, beliefs about effectiveness of risk-reducing behaviors), risk-based (i.e., risks and benefits assigned to bears, previous experience with conflict), broader (i.e., trust in the management agency, norms), and demographic influences on bear proofing behavior (Fig. 1). By identifying important drivers of compliance in this context, our intention was to explore the relative importance of factors drawn from a variety of psychological theories to inform development of more holistic approaches to understand risk-reducing behaviors that could be tested and applied in other contexts. Ultimately, this information is critical for designing efforts to promote human behaviors that reduce human–wildlife conflicts in increasingly human-dominated landscapes.

Methods

Study System

We conducted our study in Durango, Colorado, which is situated along the Animas River at an elevation of 1,988 m. Durango has grown rapidly since 1970 to a population of ~18,500 (U.S. Census Bureau 2017), resulting in increases in anthropogenic foods available to bears. These food sources are concentrated around residential development, leading to high rates of human–bear conflicts (Johnson et al. 2018). The city implemented a municipal regulation, or ordinance, in 2010 to reduce the availability of anthropogenic food to bears and other wildlife (www.durangogov.org/wildlife). The ordinance requires residents to keep garbage in a locked wildlife-resistant container or a secured location (e.g., garage or shed), except between 6:00 am and 7:00 pm on their scheduled day of garbage pickup. Enforcement by the city is based on observations by code enforcement officers and resident complaints, and violations result in fines up to $100.

Our investigation was part of a larger collaborative project with the municipal government, designed to experimentally assess the effectiveness of bear proofing on rates of garbage-related human–bear conflicts (Johnson et al. 2018). Between 2011 and 2016, researchers provided curbside bear-resistant garbage containers, free of charge, to each residential parcel within two treatment areas (Supporting Information). In 2 paired control areas, we did not provide containers. At the beginning of each summer, we canvassed treatment neighborhoods to provide instructions on appropriate use of bear-resistant containers. Treatment areas were surveyed twice a week, and if trash conflicts (i.e., strewn garbage) were observed at noncompliant parcels, we issued warnings reminding residents of the ordinance and associated fines. For the purposes of the analyses in this article, our study area was composed of only one treatment area where we could reliably assign container observations to specific households and match that to a survey response (Johnson et al. 2018).

Field Data Collection

We defined compliance with the wildlife ordinance as appropriately locking project-supplied bear-resistant containers. For a bear-resistant container to be compliant, it had to have both latches on the lid locked and all garbage stored inside the container (Supporting Information). To minimize reporting bias and assess trends over time, we monitored compliance by directly observing use of the bear-resistant containers (Nilsson et al. 2019). To align with survey sampling years (described below), we monitored compliance once per month from July through September in 2014 and 2016 on a spatially balanced, random sample of 40 city blocks (i.e., the smallest area surrounded by streets). Observations at 393 parcels occurred from 0500 to 0600 on the morning of garbage collection, when we assumed most garbage would be available to bears. Investigators recorded the compliance status of bear-resistant containers at all parcels on each block. Containers that were not visible (e.g., behind a fence or in a garage) or for which the latches were not visible were considered missing data. We calculated the annual compliance rate, our response variable, at each parcel by dividing the total number of compliant observations by the number of times a garbage container was observed, resulting in a continuous measure of the proportion of times a household was compliant (e.g., 0%, 33%, 50%, 66%, 100%).

We used 2 methods to measure the location and frequency of garbage-related conflicts at each parcel, one based on survey-reported conflicts (reported conflict, described below) and the other based on field observations of conflicts (observed conflict). To quantify observed conflict, we drove all residential streets and alleys within the treatment area looking for garbage-related conflicts (i.e., knocked over containers, strewn garbage) from July through September. We conducted monitoring on the day prior to garbage collection and on the morning of garbage collection beginning at 0500 and ending before garbage collection began (~0700). When a garbage conflict was observed, we recorded the location, type of container, and parcel address. To assess the impact of previously experienced conflicts on behavior, we used the total number of conflicts observed at the parcel the previous year. For example, to model the influence of previous experience on compliance behavior in 2014, we used the number of conflicts observed at the parcel during July–September 2013. This ensured that

only garbage-related conflicts experienced prior to compliance observations were used as a potential predictor.

Survey Data Collection

From January to April 2014 and 2016, we sent self-administered mail surveys to all residential parcels within the city limits (including but not limited to the treatment area, $n = 5{,}852$) to assess attitudes and beliefs about black bears and human-bear conflict. We administered the survey using a modified version of the Tailored Design Method (Dillman 2014) with 6 total mailings (Johnson et al. 2018). All survey materials and procedures were approved by Colorado State University's Institutional Review Board (protocol 005-17H).

We measured perceived behavioral control, perceived risks and benefits, and trust in the wildlife management agency using multi-item, Likert scales to assess latent constructs (constructs that are not directly observable; DeVellis 2012). Specifically, we adapted survey questions developed by Zajac et al. (2012) (Supporting Information) to measure these concepts, modifying question wording to fit the current study context. Personal control represented perceptions of behavioral control over conflicts (e.g., I can protect my personal property from wildlife. [5 items]). Risk and benefit represented perceived risks (e.g., I fear having an encounter with black bears. [8 items]) and benefits (e.g., Presence of black bears improves the quality of life in Durango. [4 items]) associated with bears. Agency trust (referred to in Zajac et al. [2012] as social trust) represented trust in the management agency (e.g., I am confident Colorado Parks and Wildlife can effectively manage black bears. [4 items]).

We asked respondents to report beliefs about the effectiveness of bear-resistant containers at reducing conflicts (perceived effectiveness) and overall attitudes toward bears (tolerance) by asking respondents to report their preferences for a change in the size of the bear population over 2 years (Lischka et al. 2019) (Supporting Information). To quantify reported conflict, we asked respondents to indicate the number of times over the past 2 years they experienced a bear breaking into their garbage because this type of conflict is predicted by attitude theory to be most relevant to our compliance measure (Fishbein & Ajzen 2010) (Supporting Information). We also asked residents to report whether they had experienced other bear-related conflicts that threatened the safety of humans, pets, or livestock (i.e., had a bear break into their home, know someone who was attacked or harassed by a bear [severe conflict]), which we coded as binary variables (Wilbur et al. 2018) (Supporting Information) and summed across conflict types.

We measured normative beliefs as a descriptive norm, which indicate appropriate behavior based on perceptions of what others in the area are doing (Wood et al. 2012). We measured descriptive norms by asking respondents, on a binary scale, whether they had observed anyone in their neighborhood using a bear-resistant garbage container in the past 2 years (Supporting Information). We measured demographic characteristics by asking respondents what year they were born (age), their gender (gender), and highest level of education (education), and whether they owned or rented their home (homeownership) (Supporting Information). Likert response questions contained a response option of "not sure," which were treated as missing values in analyses.

Survey Weighting

We used data from the survey of all Durango residents to determine whether weighting was necessary to accurately generalize findings (Groves 2006). After removing undeliverable addresses ($n_{2014} = 698$, $n_{2016} = 1{,}117$), our adjusted response rate for the full sample was 45% ($n = 2{,}316$) in 2014 and 45% ($n = 2{,}432$) in 2016. We used t tests ($p < 0.05$ cutoff) to determine where significant differences existed between survey responses and U.S. Census data, and weighted responses accordingly. Homeowners responded to the survey at a higher rate than renters in both years (85% of respondents were homeowners in 2014, 83% in 2016 versus 49% homeowners across Durango [U.S. Census Bureau 2017]). In addition, renters had a higher mean compliance rate than homeowners ($\bar{x}_{\text{own}} = 0.37$ [0.04], $\bar{x}_{\text{rent}} = 0.48$ [0.03], $t = 2.46$, $p < 0.05$). As a result, we weighted survey data by homeownership using the full set of responses in 2014 and 2016. We found no other statistically significant differences between respondents and nonrespondents.

Data Analyses

Because we did not know the spatial scale over which garbage-related conflict would be associated with compliance, we first used linear regression to test relationships between observed conflict and compliance rate. We calculated observed conflict within 3 areas around each parcel—20, 40, and 80 m buffers—that roughly corresponded to conflicts at the parcel, nearest neighbors, and block levels, respectively. The number of conflicts occurring within 80 m of parcel boundaries provided the best fit to compliance rate (Akaike's information criterion model weight = 0.89) and was thus retained for further compliance modeling (Burnham & Anderson 2010) (Supporting Information).

To create a single numeric indicator of each of the 4 latent constructs measured with multi-item scales, we used factor analysis to collapse responses for individual items into single measures of personal control, risk, benefit, and agency trust (Johnson 1998). Because these

Table 1. Results of simple linear regressions of factors associated with bear-proofing behavior (compliance rate) in Durango, Colorado, from field observations (observed conflicts and compliance rate) and the Living with Black Bears in Durango survey (all other variables).

					80% CIs	
Variable	n	β	*SE*	p	*Lower*	*Upper*
Observed conflicts[a]	169	0.04	0.01	0.00	0.03	0.06
Risk[a]	136	0.07	0.03	0.03	0.03	0.11
Descriptive norm[a]	160	0.23	0.16	0.15	0.03	0.44
Gender[a,b]	154	0.10	0.06	0.14	0.01	0.18
Agency trust[a]	125	−0.09	0.03	0.01	−0.13	−0.04
Homeownership[a,c]	161	−0.17	0.06	0.01	−0.25	−0.09
Benefit[a]	151	−0.08	0.03	0.01	−0.13	−0.04
Education[d]	167					
Some postsecondary		0.13	0.10	0.22	−0.01	0.27
Bachelor's degree or higher		0.01	0.10	0.89	-0.11	0.14
Reported conflict	166	0.02	0.26	0.46	−0.01	0.05
Severe conflict	168	0.02	0.08	0.85	−0.09	0.12
Tolerance	150	−0.04	0.04	0.22	−0.09	0.00
Perceived effectiveness	158	−0.05	0.07	0.44	−0.14	0.04
Personal control	142	−0.02	0.03	0.63	−0.06	0.03

[a] *80% CI excludes zero.*
[b] *Reference class is male.*
[c] *Reference class is renter.*
[d] *Reference class is high school diploma or less.*

measures were derived from previously validated scales (Zajac et al. 2012), we conducted principal axis factoring and assessed scree plots and eigenvalues to determine the appropriate number of factors to retain (Johnson 1998), confirming internal consistency with Cronbach's α (Cortina 1993) (Supporting Information).

Of the residences where we observed use of bear-resistant containers ($n = 783$ residences), 170 returned surveys in 2014 and/or 2016 ($n = 240$ total completed surveys). Where the same residence returned both surveys ($n = 70$), we randomly removed one to maintain independence ($n_{2014} = 82$, $n_{2016} = 88$). To determine the relative influence of factors influencing compliance rate, our intention was to test a single global model (Fieberg & Johnson 2015). Because our sample size was relatively small ($n = 157$) given our number of explanatory variables ($n = 13$), and we expected correlations among some variables to be high, we first conducted univariate regressions between each explanatory variable and compliance rate (Table 1). Variables with coefficients where the 80% confidence interval (CI) excluded zero were included a multiple linear regression model. The sample size for the multiple regression model was reduced ($n = 107$) because respondents had to complete all questions for all predictor variables. Prior to this analysis, we assessed multicollinearity among predictors. Where Pearson's $r > |0.60|$, we retained the variable with the stronger univariate relationship with compliance rate (Johnson 1998). All analyses were conducted in SPSS (version 24.0, Chicago, IL, U.S.A.).

Results

Respondent Characteristics

On average, respondents were 51 years old (SE 0.58, range 16–95), 55% were male, and a majority (70%) had earned at least a bachelor's degree. The mean annual number of observed conflicts in 2013 was 2.90 conflicts/block (SE 0.27, range 0–9) and in 2015 was 1.30 conflicts/block (SE 0.14, range 0–5). Observed and reported rates of garbage-related conflict were consistent. We observed that 34% of households experienced no conflicts, 32% had 1–2 conflicts, 21% 3–4 conflicts, and 13% $\geq$ 5 conflicts across both years. Similarly, 32% of respondents reported having 0 garbage-related conflicts in the past 2 years (reported conflict), 33% 1–2 conflicts, 15% 3–4 conflicts, and 17% $\geq$5 conflicts in survey responses. Most respondents (83%) had not experienced a severe conflict. Among those who did, the most commonly reported incident (17%) was knowing someone who had been harassed by a bear.

More than half (59%) of respondents reported wanting the bear population to stay the same over the next 2 years (tolerance); 25% wanted a decrease and 16% wanted an increase. A majority (61%) of respondents believed that bears improved the quality of life in Durango (an item in our benefit scale [Supporting Information]), and 71% did not fear negative interactions with bears (from risk scale). Most (72%) believed that the agency knew the appropriate methods to manage bears (from agency trust scale), and 64% believed that individuals could influence decisions about wildlife (from personal control scale).

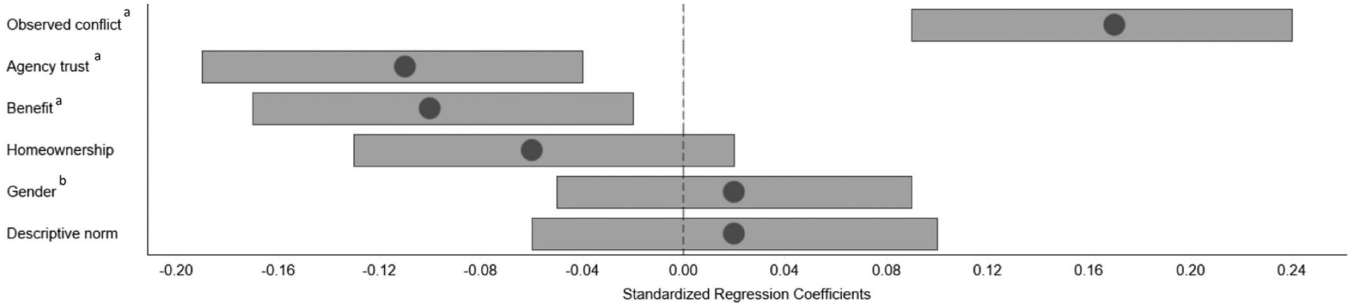

*Figure 2. Standardized regression coefficients (with 95% CIs) from a multiple regression model of bear-proofing behavior (compliance rate) in Durango, Colorado (U.S.A.) (*n = *107;* $R^2 = 0.28$*) (a, 95% CI excludes zero; b, reference class is male). Results are from field observations (observed conflicts and compliance rate) and the Living with Black Bears in Durango survey (all other variables). Homeownership and gender were categorical variables. All other variables were continuous.*

Most respondents (80%) believed that using bear-resistant garbage containers was very effective at reducing conflicts with bears (perceived effectiveness). Nearly all respondents (98%) reported using a bear-resistant garbage container at their home, and 96% reported having seen others in their neighborhood using bear-resistant containers (descriptive norm). However, our observations showed that 34% of households in 2014 and 2016 never properly locked their bear-resistant containers. Only 24% were compliant across all observations.

Compliance Modeling

To improve scale reliability, we removed 2 items from the risk and 3 from the personal control scales (Supporting Information). With these modifications, all scales, except personal control, exhibited high internal consistency (Cronbach's $\alpha > 0.60$; Cortina 1993). We retained personal control to ensure this conceptually important concept was included in our analysis, despite lower reliability metrics (Pearson's $r = 0.38$). Factor analysis results offered further confirmation for hypothesized item groupings, with all factor loadings >0.40 (DeVellis 2012).

In simple linear regression models of compliance rate, the predictors observed conflict, agency trust, risk, benefit, homeownership, gender, and descriptive norms had 80% CIs that excluded zero (Table 1). Because risk and benefit were highly correlated ($r = -0.69$) (Supporting Information), we retained benefit as it had the stronger univariate relationship with compliance rate (Table 1).

The multiple regression model explained 28% of the variation in compliance rate; observed conflict, agency trust, and benefit had 95% CIs that excluded zero (Fig. 2 & Table 2). Higher compliance rates were associated with more observed conflicts on a respondent's block. Households with ≥50% compliance had a mean of 2.68 conflicts on their block in the previous summer (SE 0.26, range 0–9), whereas households with <50% compliance had a mean of 1.51 conflicts on their block the previous summer (SE 0.22, range 0–9). Higher levels of agency trust were associated with lower rates of compliance. To illustrate, in one item of our agency trust scale, 84% of households that were never compliant agreed that the agency responded appropriately to human-bear conflicts, compared to 68% of households that were compliant on at least one observation. Similarly, greater perceived benefits from bears were associated with lower compliance, where households that were compliant on ≥50% of observations had a lower mean benefit score ($\bar{x} = -0.04$ [SE 0.12], range = −2.37 to 1.59) than households compliant on <50% of observations ($\bar{x} = 0.36$ [0.09], range = −2.37 to 1.59).

Table 2. Results of multiple regression model ($n = 107$) of factors associated with bear-proofing behavior (compliance rate) in Durango, Colorado, from field observations (observed conflicts and compliance rate) and the Living with Black Bears in Durango survey (all other variables).[a]

	Standardized values				
				95% CIs	
Variable	*β*	*SE*	p	*Lower*	*Upper*
Intercept	0.49	0.04	0.00	0.42	0.56
Agency trust[b]	−0.11	0.04	0.00	−0.19	−0.04
Observed conflict[b]	0.17	0.04	0.00	0.09	0.240
Benefit[b]	−0.10	0.04	0.01	−0.17	−0.02
Homeownership	−0.06	0.04	0.12	-0.13	0.02
Gender[c]	0.02	0.04	0.50	−0.05	0.09
Descriptive norm	0.02	0.04	0.66	−0.06	0.10

[a] *The* R^2 *value is 0.28 and dependent variable is compliance rate.*
[b] *The 95% CI excludes zero.*
[c] *Reference class is male.*

Discussion

Through a combination of behavioral observations and quantitative surveys, we explored the drivers of

a behavior critical for reducing a prevalent type of human–wildlife conflict that occurs throughout North America—human–black bear conflict associated with anthropogenic foods (Hristienko & McDonald 2007). We found that previous conflicts incurred by individuals and their neighbors, trust in the management agency, and perceived benefits of bears were key factors affecting compliance with a local ordinance requiring the use of bear-resistant garbage containers. While the relative importance of behavioral drivers may vary across contexts, we assessed the influence of psychological concepts arising from theory and a broad suite of previous research to advance a comprehensive approach that not only proved valuable in our bear case study, but also warrants testing in other systems. Behavior change campaigns informed by these findings may be more effective in promoting compliance, and other conservation-related behaviors, than those attempting to merely increase knowledge of how to act through information provision (McKenzie-Mohr 2011).

Of all factors assessed, the number of garbage-related conflicts with bears on one's block in the previous year, measured by field observations, was the strongest influence on compliance. Frequent conflicts are likely to increase residents' perceptions of risk (Slovic 1987), whether one experiences conflicts directly or observes them in their neighborhood. We found that the number of garbage-related conflicts reported on surveys was not an important predictor of compliance, indicating that direct outcomes of conflict for individuals may be less important in driving risk-reducing behaviors than perceptions of the commonness of conflict in the area where one lives.

We found that increased trust in the wildlife management agency was associated with reduced compliance. Individuals who reported high levels of trust were more likely to believe that the agency was capable of and currently implementing appropriate management of bears and conflicts and may therefore believe that their own actions to reduce conflicts are unnecessary. Trust may reflect an external locus of control, where individuals believe institutional response is sufficient and potentially more effective than individual action. Perceptions of outcomes of management affect behavior in other settings, such as hunter participation in wildlife-disease management (Rudolph & Riley 2014). Our results suggest that messages emphasizing the critical role of individual action in determining the effectiveness of agency efforts to limit conflict may help increase compliance behavior.

Similar to our findings for trust, perceived benefits and compliance were negatively related; individuals who perceived greater benefits of bears were less likely to secure their garbage. In related work, we found that individuals who perceive more benefits also have a higher tolerance for bears (Lischka et al. 2019). Therefore, we suspect that residents who perceive more benefits may be more tolerant of the negative consequences of living with wildlife, resulting in decreased compliance behavior.

To apply our results to behavior change efforts, nuance will be necessary. Conventional, knowledge-based messages designed to increase risk-reducing behaviors often focus on potential lethal outcomes of conflict for wildlife. These types of efforts, in general, have little impact on human behaviors (Ardoin 2013). A focus on the potential for individual actions to reduce conflict and maintain the benefits of wildlife to communities and ecosystems (e.g., maintain populations for hunting and viewing, reduce the need for lethal removal) may be more productive in convincing people to take action to reduce risks.

While we found evidence to support the influence of some psychological variables (benefits, agency trust) on compliance, we found limited evidence of the influence of other attitude concepts (tolerance, perceived effectiveness, personal control). These findings support recent calls by social scientists to look beyond efforts to simply change attitudes to modify human behavior (Nilsson et al. 2019). Intervening barriers to action (e.g., the cost or inconvenience of risk-reducing behaviors) can weaken the influence of attitudes on behavior and result in individuals not taking action, despite positive attitudes (McKenzie-Mohr 2011). Thus, behavior change efforts that focus on improving attitudes toward risk-reducing behaviors may be necessary to increase the number of people willing to act, but may not be sufficient to improve rates of behavior adoption.

Limitations and Future Research

We quantified compliance behavior by directly observing use of bear-resistant garbage containers, rather than depending on self-reported behaviors from survey responses. While observations yielded more accurate data, our observations were constrained by the difficulty of determining appropriate use of the containers. For example, in 2014, garbage containers were not visible at 213 parcels (of 393 observed) during a single round of observations, leaving it unclear whether garbage was available to bears but not visible to observers or garbage was secured in a garage or shed. As a result, our findings shed light on the reasons residents choose to use (or not use) bear-resistant containers, but not on other forms of compliance. In designing future explorations of risk-reducing behaviors, researchers will need to assess the trade-off between more accurate observations of a single or small number of behaviors and less accurate self-reports of a suite of behaviors collected through survey responses.

Exploring broad barriers to action, as well as leveraging these concepts in behavior-change initiatives, are important areas for future research. For example, social norms can be a strong influence, suggesting that the

creation and propagation of norms could be an effective way to modify human behavior (Farrow et al. 2017). Although we found that observed conflicts at neighboring parcels affected compliance, perceptions of others' behavior (a form of descriptive norm) were not an important influence. Because we distributed bear-resistant containers to all residents of the treatment area, leading to 96% of respondents reporting that they had seen others bear proofing, we were limited in detecting a meaningful influence on compliance. Future work could be improved by assessing alternative metrics (e.g., measuring beliefs about expected behaviors), exploring who creates and reinforces norms, and examining how different normative pressures affect behavior (St. John et al. 2010).

Additional research is also needed to refine understanding of how to increase the adoption of risk-reducing behaviors. Future research could investigate the importance of long-term exposure to conflicts and habit formation, as well as the influence of perceived responsibility for conflict management on compliance. In our work, we removed a significant barrier to compliance by providing free bear-resistant containers to residents. In many communities facing high levels of human-wildlife conflicts, however, such intensive interventions may not be financially or logistically feasible. Therefore, an exploration of the logistical, financial, and social barriers to strategies that proactively minimize conflict is essential. Finally, our work draws primarily on individual-level influences to understand compliance behavior. To further understanding of the influence of broader-level (e.g., group, institutional) factors on behavior, research should be designed in collaboration with professionals from other social science disciplines such as political science, sociology, and economics.

Despite widespread recognition that promoting risk-reducing human behavior is key to reducing human–wildlife conflicts (Nyhus 2016), there is a relative lack of knowledge of the factors that lead to those behaviors. Further, there is a need for greater attention to direct assessments of behaviors, rather than simply relying on attitudes as behavioral indicators (Nilsson et al. 2019). Using a unique combination of survey and observational data, we were able to evaluate the relative influence of attitudinal, risk-based, broader, and demographic factors hypothesized to influence behavior to inform development of more effective behavior change efforts. Based on our findings that previous conflicts incurred by individuals and their neighbors, trust in the management agency, and perceived benefits of bears had the greatest influence, we suggest that conservation practitioners may empower individuals to act to reduce human–wildlife conflicts using messages that link successful management of conflicts to individual actions and emphasize how reducing conflicts could maintain benefits provided by wildlife. While the relative importance of these influences will likely change with socio-ecological and cultural context, we expect these to be important drivers of risk-reducing behaviors in comparable human–wildlife conflict situations. We also suggest that application and evaluation of behavior change efforts guided by quality social science information will be a critical real-world test of the utility of leveraging psychological information to increase compliance with local ordinances (Osbaldiston 2013).

Acknowledgments

This project was funded by Colorado Parks and Wildlife, USDA National Wildlife Research Center, Anheuser-Busch Environmental Fellowship, and Hill Memorial Fellowship. We thank residents of the City of Durango for their time in completing surveys and the following individuals for field assistance: S. Coons, C. Jager, D. Lewis, J. Meighan, L. Mengak, R. Wilbur, and L. Willmarth. We thank G. Wittemyer, M. Quartuch, M. Viera, and anonymous reviewers for improving the manuscript.

Supporting Information

Study area map (Appendix S1), photos of bear-resistant containers (Appendix S2), survey questions (Appendix S3), model results on buffer size (Appendix S4), scale variable information (Appendix S5), and correlations among predictors (Appendix S6) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

Literature Cited

Ardoin N, Heimlich J, Braus J & Merrick C. 2013. Influencing conservation action: What research says about environmental literacy, behavior, and conservation results. National Audubon Society, New York.

Burnham KP, Anderson DA. 2010. Model selection and multimodel inference: a practical information-theoretic approach. 2nd edition. Springer, New York.

Chapron G, et al. 2014. Recovery of large carnivores in Europe's modern human-dominated landscapes. Science **346:**1517–1519.

Cialdini RB, Kallgren CA, Reno RR. 1991. A focus theory of normative conduct - a theoretical refinement and reevaluation of the role of norms in human-behavior. Advances in Experimental Social Psychology **24:**201–234.

Cortina JM. 1993. What is coefficient alpha - an examination of theory and applications. Journal of Applied Psychology **78:**98–104.

DeVellis RF. 2012. Scale development: theory and applications. SAGE, Thousand Oaks, California.

Dillman DA. 2014. Internet, phone, mail, and mixed-mode surveys: the tailored design method. Wiley, Hoboken, New Jersey.

Don Carlos AW, Bright AD, Teel TL, Vaske JJ. 2009. Human-black bear conflict in urban areas: an integrated approach to management response. Human Dimensions of Wildlife **14:**174–184.

Eagly AH, Chaiken S. 1993. The psychology of attitudes. Harcourt Brace Jovanovich, Orlando, Florida.

Farrow K, Grolleau G, Ibanez L. 2017. Social norms and pro-environmental behavior: a review of the evidence. Ecological Economics **140:**1–13.

Fishbein M, Ajzen I. 2010. Predicting and changing behavior: the reasoned action approach. Routledge, New York.

Fieberg J, Johnson DH. 2015. MMI: multimodel inference or models with management implications? Journal of Wildlife Management **79:**708–718.

Gezelius SS. 2002. Do norms count? State regulation and compliance in a Norwegian fishing community. Acta Sociologica **45:**305–314.

Gore ML, Wilson RS, Siemer WF, Hudenko HW, Clarke CE, Hart PS, Maguire LA, Muter BA. 2009. Application of risk concepts to wildlife management: special issue introduction. Human Dimensions of Wildlife **14:**301–313.

Groves RM. 2006. Nonresponse rates and nonresponse bias in household surveys. Public Opinion Quarterly **70:**646–675.

Hayman RB, Harvey RG, Mazzotti FJ, Israel GD, Woodward AR. 2014. Who complains about alligators? Cognitive and situational factors influence behavior toward wildlife. Human Dimensions of Wildlife **19:**481–497.

Hristienko H, McDonald JE. 2007. Going into the 21(st) century: a perspective on trends and controversies in the management of the American black bear. Ursus **18:**72–88.

Johnson DE. 1998. Applied multivariate methods for data analysts. Duxbury Press, Pacific Grove, California.

Johnson HE, Lewis DL, Breck SW. 2020. Individual and population fitness consequences associated with large carnivore use of residential development. Ecosphere **11:**e03098.

Johnson HE, Lewis DL, Lischka SA, Breck SW. 2018. Assessing ecological and social outcomes of a bear-proofing experiment. Journal of Wildlife Management **82:**1102–1114.

Kahler JS, Gore M. 2012. Beyond the cooking pot and pocket book: factors influencing noncompliance with wildlife poaching rules. International Journal of Comparative and Applied Criminal Justice **36:**103–120.

Kahler JS, Roloff GJ, Gore ML. 2013. Poaching risks in community-based natural resource management. Conservation Biology **27:**177–186.

Keane A, Jones JPG, Edwards-Jones G, Milner-Gulland EJ. 2008. The sleeping policeman: understanding issues of enforcement and compliance in conservation. Animal Conservation **11:**75–82.

Laufenberg JS, Johnson HE, Doherty PF Jr, Breck SW. 2018. Compounding effects of human development and a natural food shortage on a black bear population along a human development-wildland interface. Biological Conservation **224:**188–198.

Lewis DL, Baruch-Mordo S, Wilson KR, Breck SW, Mao JS, Broderick J. 2015. Foraging ecology of black bears in urban environments: guidance for human-bear conflict mitigation. Ecosphere **6:**141.

Lischka SA, Teel T, Johnson H, Crooks K. 2019. Understanding and managing tolerance for a large carnivore in a residential system. Biological Conservation, **238:**108189. https://doi.org/10.1016/j.biocon.2019.07.034.

Lischka SA, Teel T, Johnson H, Reed SE, DonCarlos A, Crooks K. 2018. A conceptual model to guide understanding of ecological and social factors leading to human-wildlife conflicts. Biological Conservation **225:**80–87.

Marley J, Hyde A, Salkeld JH, Prima MC, Parrott L, Senger SE, Tyson RC. 2017. Does human education reduce conflicts between humans and bears? An agent-based modelling approach. Ecological Modelling **343:**15–24.

McKenzie-Mohr D. 2011. Fostering sustainable behavior: an introduction to community-based social marketing. New Society, Philadelphia, Pennsylvania.

Morzillo AT, Mertig AG, Hollister JW, Garner N, Liu JG. 2010. Socioeconomic factors affecting local support for black bear recovery strategies. Environmental Management **45:**1299–1311.

Nilsson D, Fielding K, Dean AJ. 2019. Achieving conservation impact by shifting focus from human attitudes to behaviors. Conservation Biology https://doi.org/10.1111/cobi.13363.

Nyhus PJ. 2016. Human–wildlife conflict and coexistence. Annual Review of Environment and Resources **1:**143–171.

Osbaldiston R. 2013. Synthesizing the experiments and theories of conservation psychology. Sustainability **5:**2770–2795.

Ripple WJ, etal. 2014. Status and ecological effects of the World's largest carnivores. Science **343:**1241484. https://doi.org/10.1126/science.1241484.

Rudolph BA, Riley SJ. 2014. Factors affecting hunters' trust and cooperation. Human Dimensions of Wildlife **19:**469–479.

Schultz PW. 2011. Conservation Means Behavior. Conservation Biology **25:**1080–1083.

Slovic P. 1987. Perception of risk. Science **236:**280–285.

St. John FAV, Edwards-Jones G, Jones JPG. 2010. Conservation and human behaviour: lessons from social psychology. Wildlife Research **37:**658–667.

St. John FAV, Mai CH, Pei KJC. 2015. Evaluating deterrents of illegal behaviour in conservation: carnivore killing in rural Taiwan. Biological Conservation **189:**86–94.

Triezenberg HA, Gore ML, Riley SJ, Lapinski MK. 2014. Perceived risks from disease and management policies: an expansion and testing of a zoonotic disease risk perception model. Human Dimensions of Wildlife **19:**123–138.

United States Census Bureau. 2017. Durango, Colorado QuickFacts. Available from https://www.census.gov/quickfacts/fact/table/durangocitycolorado/PST045217 (accessed October 12, 2017).

Wilbur RC, Lischka SA, Young JR, Johnson HE. 2018. Experience, attitudes, and demographic factors influence the probability of reporting human–black bear interactions. Wildlife Society Bulletin **42:**22–31.

Wood MM, Mileti DS, Kano M, Kelley MM, Regan R, Bourque LB. 2012. Communicating actionable risk for terrorism and other hazards? Risk Analysis **32:**601–615.

Woodroffe R, Thirgood S, Rabinowitz A. 2005. People and wildlife: conflict or co-existence? Cambridge University Press, Cambridge, UK.

Zajac RM, Bruskotter JT, Wilson RS, Prange S. 2012. Learning to live with black bears: a psychological model of acceptance. Journal of Wildlife Management **76:**1331–1340.