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Contributed Paper

Global patterns and trends in human–wildlife conflict compensation

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Abstract: *Human–wildlife conflict is a major conservation challenge, and compensation for wildlife damage is a widely used economic tool to mitigate this conflict. The effectiveness of this management tool is widely debated. The relative importance of factors associated with compensation success is unclear, and little is known about global geographic or taxonomic differences in the application of compensation programs. We reviewed research on wildlife-damage compensation to determine geographic and taxonomic gaps, analyze patterns of positive and negative comments related to compensation, and assess the relative magnitude of global compensation payments. We analyzed 288 publications referencing wildlife compensation and identified 138 unique compensation programs. These publications reported US$222 million (adjusted for inflation) spent on compensation in 50 countries since 1980. Europeans published the most articles, and compensation funding was highest in Europe, where depredation by wolves and bears was the most frequently compensated damage. Authors of the publications we reviewed made twice as many negative comments as positive comments about compensation. Three-quarters of the negative comments related to program administration. Conversely, three-quarters of the positive comments related to program outcomes. The 3 most common suggestions to improve compensation programs included requiring claimants to employ damage-prevention practices, such as improving livestock husbandry or fencing of crops to receive compensation* (n = *25, 15%); modifying ex post compensation schemes to some form of outcome-based performance payment* (n = *21, 12%); and altering programs to make compensation payments more quickly* (n = *14, 8%). We suggest that further understanding of the strengths and weaknesses of compensation as a conflict-mitigation tool will require more systematic evaluation of the factors driving these opinions and that differentiating process and outcomes and understanding linkages between them will result in more fruitful analyses and ultimately more effective conflict mitigation.*

Keywords: biodiversity, coexistence, mitigation

Patrones Globales y Tendencias de la Compensación del Conflicto Humano – Fauna Silvestre

Resumen: *El conflicto humano – fauna silvestre es un enorme reto para la conservación, y la compensación del daño hecho a la fauna es una herramienta única utilizada ampliamente para mitigar este conflicto. La efectividad de esta herramienta de manejo se debate ampliamente. La importancia relativa de los factores asociados con el éxito de la compensación no es clara y se sabe poco sobre las diferencias geográficas o taxonómicas en la aplicación de los programas de compensación. Revisamos las investigaciones sobre la compensación del daño a la fauna para determinar los vacíos geográficos y taxonómicos, analizar los patrones de los comentarios positivos y negativos relacionados con la compensación, y valorar la magnitud relativa de los pagos de compensación global. Analizamos 288 publicaciones con referencias a la compensación de fauna e identificamos 138 programas únicos de compensación. Estas publicaciones reportaron USD $222 millones (ajustados a la inflación) gastados en la compensación en 50 países desde 1980. Los europeos publicaron la mayoría de los artículos, y el financiamiento de la compensación fue más alto en Europa, en donde la depredación por lobos y osos fue el daño compensado con mayor frecuencia. Tres-cuartos de los comentarios negativos se relacionaron con la administración del programa. Al contrario, tres-cuartos de los comentarios*

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***Article Impact Statement**: Compensation is key to human–wildlife conflict resolution, but improved evaluation of prevention and mitigation methods is needed.*

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*positivos se relacionaron con los resultados de los programas. Las tres sugerencias más comunes para mejorar los programas de compensación incluyeron requerir que los solicitantes emplearan prácticas de prevención del daño, como la mejora de la crianza de ganado o la colocación de cercas alrededor de cultivos para recibir compensación (*n *= 25, 15%); modificar los esquemas post-modificación anteriores en alguna forma de pago de desempeño basado en el resultado (*n *= 21, 12%); y alterar los programas para realizar pagos de compensación de forma más rápida (*n *= 14, 8%). Sugerimos que el futuro entendimiento de las fortalezas y debilidades de la compensación como herramienta en la mitigación del conflicto requerirá evaluaciones más sistemáticas de los factores que conducen a estas opiniones y que diferenciar los procesos y resultados y entender las conexiones entre ellos resultará en análisis más fructíferos, y finalmente una mitigación de conflictos más efectiva.*

Palabras Clave: biodiversidad, coexistencia, mitigación

Introduction

Human–wildlife conflict is an important conservation challenge because livestock predation, crop and property damage, and threats to human safety frequently trigger retaliatory killing of wildlife (Woodroffe et al. 2005; Dirzo et al. 2014; Ripple et al. 2014; Ripple et al. 2015; Nyhus 2016). Even when animals like wolves or lions are not directly involved in harming people or their property, debates over the risks and values associated with conserving these species may lead to social conflict (Redpath et al. 2015b).

One approach to reducing conflict between wildlife and people is to prevent it from occurring in the first place (Treves & Karanth 2003). Lethal control, such as legally sanctioned hunting and selective harvesting or illegal retaliation, has been widely used throughout history to eliminate sources of wildlife conflict (Sillero-Zubiri & Laurenson 2001; Conover 2002; Thirgood et al. 2005). Nonlethal measures to prevent conflict are also widely employed, such as fencing, livestock corrals, and guard animals (Reidinger & Miller 2013).

Another approach to promote human–wildlife coexistence is to mitigate the impact of conflict once it occurs (Woodroffe et al. 2005). One way to do this is to provide economic incentives, such as revenue sharing from wildlife tourism or trophy hunting, to increase tolerance of wildlife damage (Loveridge et al. 2006; Dickman et al. 2011). These efforts are generally intended to discourage retaliatory killing, reduce public opposition to wildlife conservation, or shift some of the costs of living with wildlife from those who experience the damage to those who support conservation (Woodroffe et al. 2005; Schwerdtner & Gruber 2007).

Compensation is one of the most widely used of these economic postconflict mitigation tools (Schwerdtner & Gruber 2007; Dickman et al. 2011; Tveraa et al. 2014). Wildlife compensation typically involves reimbursing individuals for lost livestock or crops through monetary payments or nonmonetary compensation such as replacement animals or food and supplies (Nyhus et al. 2005). Governments or nongovernmental organizations may compensate individuals after damage occurs (ex post compensation) or make payments based on expected conflict (payment in advance) or estimated wildlife abundance or reproduction (performance payments) (Nyhus et al. 2005; Dickman et al. 2011). Recipients may be required to pay premiums to participate in insurance-based compensation (Chen et al. 2013; Marino et al. 2016). Compensation schemes typically require documentation or expert verification of wildlife damage and may require certain damage-prevention measures such as livestock corrals (Nyhus et al. 2005).

Despite the ubiquity of wildlife compensation programs, there is widespread disagreement over the efficacy of these programs. Critics argue that compensation programs can be administratively inefficient and may serve as agricultural subsidies, perversely leading to crop and livestock expansion and ultimately reducing wildlife populations (Bulte & Rondeau 2005; Rondeau & Bulte 2007). Supporters argue that compensation can mitigate the negative impacts of conflict and reduce incentives for lethal retaliation (Yoder 2000).

Although the application of compensation as a conflict-mitigation tool is widespread, the reasons for the diversity of opinions regarding the benefits and drawbacks of this approach are unclear. Little is known about geographic or taxonomic differences in the application of compensation programs. Nyhus et al. (2003) report on a survey of compensation practitioners and identify factors likely to lead to more effective compensation programs. These factors include more rapid verification and payment, sufficient and sustainable payment, and reduced administrative burden (Nyhus et al. 2003). Whether some of these factors are broadly considered more important relative to other factors, however, is also unclear.

We reviewed the wildlife-damage compensation literature to examine whether there are geographic or taxonomic gaps in compensation scholarship and explore patterns that divide researchers and practitioners favoring and opposing the use of compensation as a tool to mitigate human–wildlife conflict. We examined whether these differences reflect author comments focused on the management of compensation programs (process) or the outcomes of these programs (results). We used the framework developed by Nyhus et al. (2003) to examine which

factors hypothesized to promote effective compensation programs are discussed and recommended more than others. To our knowledge this is the first detailed analysis of a substantial portion of the wildlife compensation literature and the first global estimate of the number and extent of compensation payments.

Methods

We collected English-language scholarly publications (journal articles, books, book chapters, government and nongovernmental reports, scholarly newsletters and bulletins, and theses and dissertations) published before August 2015 that referred to programs in which compensation was used as a tool to manage human–wildlife conflict. We included articles focusing on compensation and those describing compensation as part of a discussion or recommendation. We used the search engines Agricola, Biodiversity Heritage Library, Environment Complete, Environmental Impact, Google Scholar, JSTOR, OneSearch, Scopus, Science Direct, and Wildlife Ecology and Studies Worldwide. We used the following keywords singly and in combination: compensation, wildlife, human wildlife conflict, and damage compensation. We added geographic identifiers to the search terms on Google Scholar, OneSearch, and Scopus. In cases of searches with large numbers of results, the first 200 abstracts were checked for relevance. We examined and included if appropriate "related articles" identified through Science Direct. We searched for relevant literature cited in the articles resulting from our searches. We also searched for the following terms on Google Scholar's Spain, Mexico, and Panama sites: compensación animales silvestres, compensación para conflicto fauna humana latinoamericana, and conflicto entre seres humanos y vida silvestre.

We collected summary data relating to compensation and data on individual compensation schemes referenced within these publications. For each publication, we documented author names, continent where compensation takes place, positive and negative comments made by the authors about compensation, author suggestions to improve compensation programs, and author definitions of success of a compensation scheme.

For each individual compensation scheme referenced by a publication (some publications referenced more than one scheme), we recorded the following characteristics: author and date of paper, continent, country, start and end date, eligibility or payment rules, requirements for conflict mitigation, average number of days to receive payment, payment type (ex post, payment in advance, insurance claim), species causing damage, and amount paid each year. We converted amounts paid each year into 2014 inflation-adjusted U.S. dollars based on historical exchange rates published by the U.S. Department of Agriculture Economic Research Service (http://www.ers.usda.gov). We documented the existence of a compensation scheme in Mexico (Fondo de Aseguramiento Ganadero 2010) but did not include its source, a webpage (http://www.fondocnog.org.mx/), in the literature analysis.

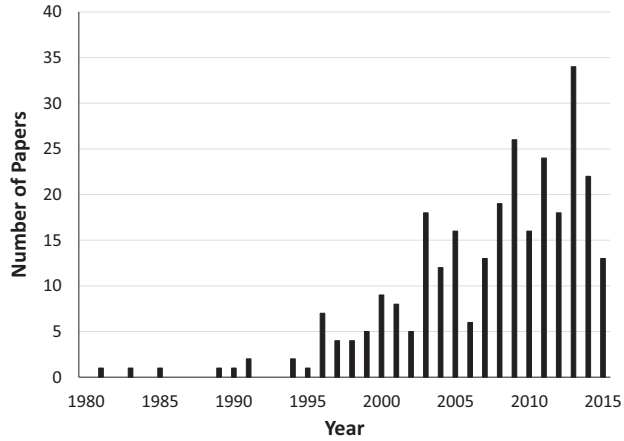

Figure 1. Number of scholarly publications (1980–2015) relating to financial compensation as a tool to manage human-wildlife conflict.

We categorized comments about compensation by summarizing all comments and organizing comments based on five categories hypothesized by Nyhus et al. (2003) to be ingredients of successful compensation programs—prompt and fair payment, clear rules and guidelines, sufficient and sustainable funds, site specificity, quick and accurate verification, and measures of success. We further classified comments as positive or negative. For example, the phrase payment too slow was coded as a negative comment related to prompt and fair payment generally and long wait times for payment more specifically. These coded comments were separated into those associated with the process of running a compensation scheme (e.g., payment amounts, speed of payment) and the results of the compensation scheme (e.g., fewer retaliatory killings, lack of reduction in hostility toward wildlife). Locations were coded by country and mapped with ArcGIS version 10.3.1 (ESRI 2015).

Results

We found 288 publications referencing compensation for human-wildlife conflict (Supporting Information). The aggregate number of publications increased steadily over time from <1/year on average in the 1980s to 24 in 2014 (Fig. 1). We identified 138 unique compensation schemes. A large majority ($n = 121$, 88%) were ex post compensation schemes, followed by insurance schemes requiring those affected to pay at least partial premiums to cover potential losses ($n = 10$, 7%), a combination of ex post payments and payments in advance ($n = 4$, 3%),

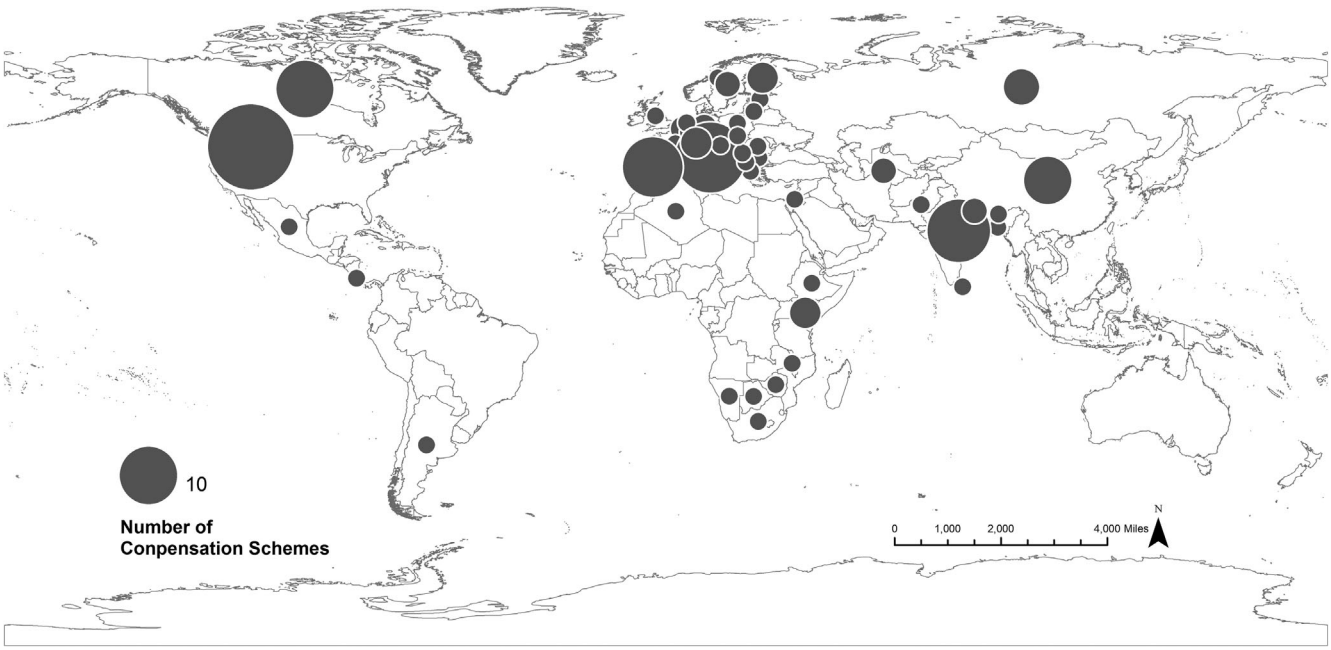

Figure 2. Relative number of wildlife-damage compensation schemes found in a review of scholarly publications on the topic by country 1980–2015.

payments only in advance ($n = 2$, 1%), and payment for capturing a carnivore alive after it caused damage ($n = 1$, 1%). We identified 130 of the schemes as apparently still operating in 2015.

We documented compensation schemes in 50 countries (Fig. 2). The prevalence of compensation schemes was greatest in Europe, followed by North America, Asia, and Africa (Fig. 3). Few schemes cited in the scholarly literature were in South America or Central America, and we found no published examples of programs in Australia. A minimum of $168 million ($222 million measured in adjusted 2014 dollars) was reportedly paid out from 1980 to 2015. An additional $8 million ($33 million adjusted) was paid out when we included texts published since 1964, but we did not include pre-1980 estimates in our analysis because of the limited number of papers and even more limited payment data for this period. The geographic distributions of these funds mirrored the distribution of compensation programs; approximately $140 million (63%) was reported in the papers describing programs in Europe (Fig. 3).

Compensation programs were dominated by those focused on large animals (Fig. 4). Out of the 105 schemes for which species data were available, a majority included the order carnivora ($n = 85$, 81%). The largest cats in the family Felidae (cheetahs [*Acinonyx jubatus*], mountain lions [*Puma concolor*], leopards [*Panthera pardus*], lions [*Panthera leo*], lynx [*Lynx lynx*], snow leopards [*Panthera uncia*], and tigers [*Panthera tigris*]) accounted for one-third of all schemes ($n = 35$, 33%). Almost half the programs involved Canidae ($n = 47$, 45%),

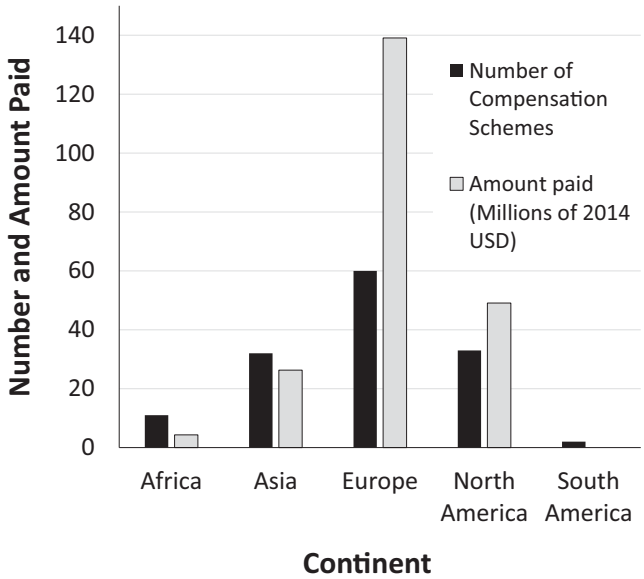

Figure 3. Number of wildlife-damage compensation schemes and amount of compensation paid on each continent 1980–2015.

Ursidae represented just under one-third of programs ($n = 32$, 30%), and Elephantidae represented 11 (10%). Wolves accounted for almost all of the canid schemes and thus the most schemes of any unique taxonomic group ($n = 41$, 39%). Livestock losses represented the most common reason for wildlife compensation out of the 122 schemes with this information ($n = 103$, 84%), followed by crop damage ($n = 43$, 35%) and human injury or death

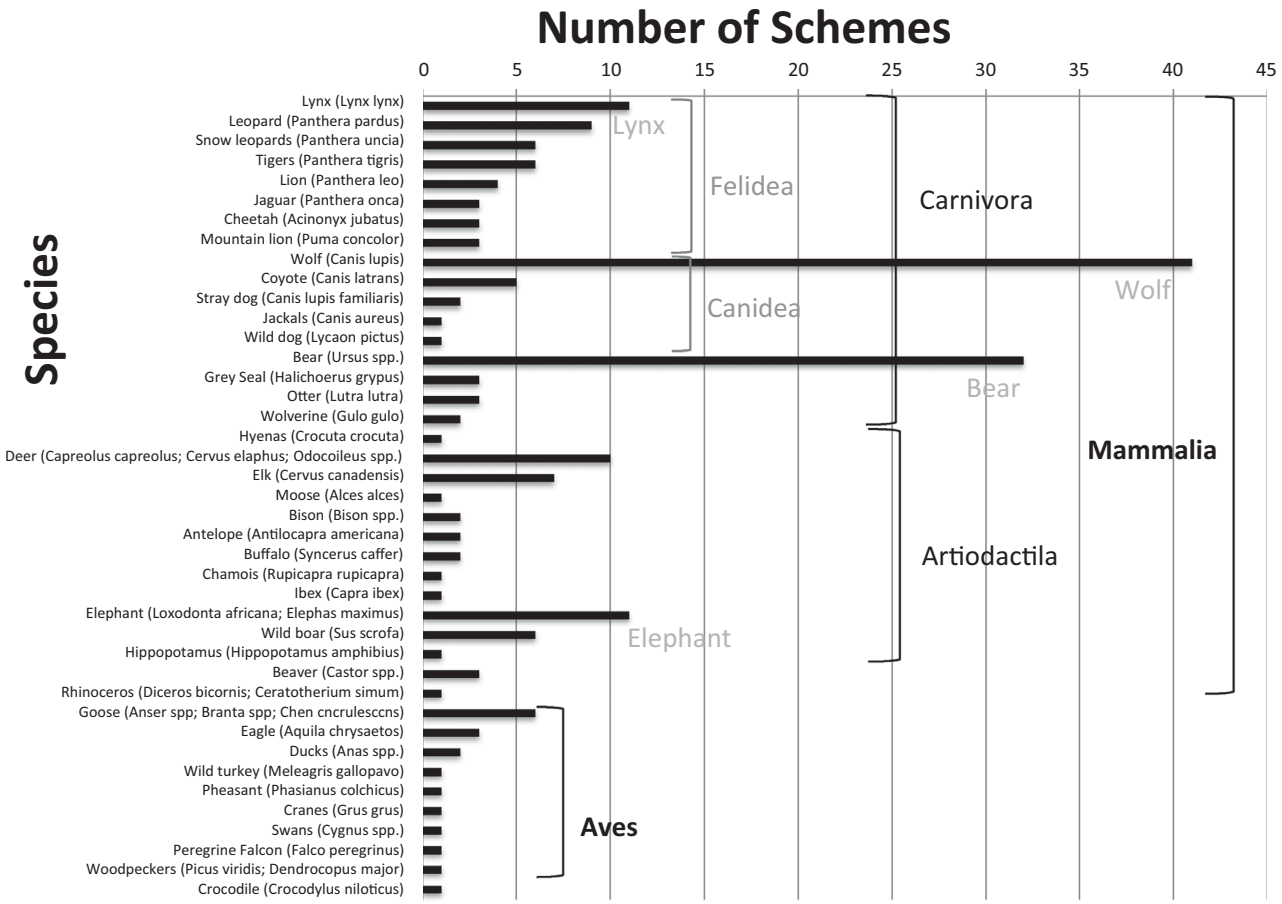

*Figure 4. Number of wildlife-damage compensation schemes described in scholarly publications that explicitly accounted for damage by a particular species group (*n *= 202).*

(n = 14, 11%). Thirty (25%) of the schemes provided compensation for both crop and livestock losses.

The amount of time between the damage event and the payment of compensation varied widely. For the 33 cases where these data were available, 6% (n = 2) of schemes made payments in <1 week, 15% (n = 5) made payments in <1 month, 82% (n = 27) paid in <6 months, and 18% (n = 6) took over 6 months.

Authors of the papers we examined made more than twice as many negative comments regarding compensation (n = 404, 69%) as positive comments (n = 183, 31%) (Table 1). Approximately three-quarters of the negative comments (73%) were related to the operation of the compensation scheme. The most common negative process-related comments were that payments were too low (12%), funding was unsustainable (7%), and payments were too slow (7%). Just over three-quarters of the positive comments (77%) were related to the outcomes of compensation programs. The most common positive comments were that compensation programs help people with economic losses related to human wildlife conflicts (17%); increase fairness by spreading the cost of wildlife damage to those who want to conserve wildlife (14%); and improve attitudes toward wildlife (14%) (Supporting Information).

Table 1. Number of positive and negative comments made by authors of pieces on wildlife-damage compensation relating to the results of and process of administrating the compensation scheme*.

	Negative		*Positive*	
	n	%	*n*	%
Results	106	26.2	140	76.5
Process	298	73.8	43	23.5
Total	404	100.0	183	100.0

** Ten positive and 9 negative comments were excluded because they were not specific.*

When organized by core elements hypothesized by Nyhus et al. (2003) (n = 597 due to inclusion of vague comments such as "it is effective or not effective" that were excluded from other classifications), almost three-quarters of all negative comments related to measures of success, prompt and fair payment, and sufficient and sustainable funds. The remainder addressed site specificity, clear rules and guidelines, and quick and accurate verification (Table 2). Almost two-thirds of all of

Table 2. Negative and positive comments about compensation schemes made in the literature on wildlife-damage compensation organized by core elements of compensation proposed by Nyhus et al. (2003).

	Comments						*Suggested improvements*	
	negative		*positive*		*Total*			
Core element	*n*	%	*n*	%	*n*	%	*n*	%
Quick and accurate verification	26	4.4	9	1.5	35	6.0	8	4.6
Prompt and fair payment	104	17.7	32	5.5	136	23.2	47	27.2
Sufficient and sustainable funds	67	11.4	6	1.0	73	12.4	25	14.5
Site specificity	38	6.5	21	3.6	59	10.1	10	5.8
Clear rules and guidelines	53	9.0	0	0.0	53	9.0	50	28.9
Measures of success	116	19.8	115	19.6	231	39.4	5	2.9
Other	N/A	N/A	N/A	N/A	N/A	N/A	28	16.2
Total	404	68.8	183	31.2	587	100	173	100

the positive comments addressed measures of success by mentioning outcomes.

When we assessed recommendations made by authors for improving compensation programs, almost two-thirds of recommendations in the 121 papers that provided suggestions ($n = 173$ total comments) mentioned how payments are made, requirements, concerns over funding, and payment amounts. Additional comments addressed participation, speed of payment, governance, noncompensation forms of mitigation, and verification. The 3 most frequently noted specific recommendations were that claimants should be required to use damage-prevention practices, such as improving livestock husbandry or fencing of crops, to receive compensation ($n = 25$, 14%); ex post compensation schemes should be changed to some form of outcome-based performance payment ($n = 21$, 12%); and programs should make compensation payments more quickly ($n = 14$, 8%) (Supporting Information).

When the suggestions for improvement were categorized based on the five core elements of effective compensation programs (Nyhus et al. 2003), approximately two-thirds of all suggestions addressed just two of the five elements. Slightly fewer than one-third of the suggestions related to improving clear rules and guidelines, such as public awareness of the program and clear information on how to document and submit a claim (Table 2), and a similar number suggested improvements in the area of prompt and fair payment (i.e., increasing compensation payments and making them more quickly). Five percent of comments related to the need for quick and accurate verification, and 3% related to identifying clear measures of success (Table 2).

Discussion

Wildlife-damage compensation scholarship has grown rapidly in recent years and has become an important contribution to the human–wildlife conflict literature. For example, the academic search engine Scopus identified 111 articles on human–wildlife conflict in 2014, and we identified 24 scholarly publications that mentioned compensation in that same year. Although compensation programs are used in many regions of the world, there are important geographic and taxonomic differences in the application of these programs and mixed messages about the effectiveness of compensation as a tool for mitigation of human–wildlife conflict.

It was striking that compensation scholarship was most extensive in Europe, followed by North America and Asia, and least common in Africa, South America, and Australia. This geographic imbalance is mirrored by the large mammals addressed in the literature that live in these regions; wolves and bears (widespread in Europe, North America, and Asia) represented the most common target of compensation, followed by lynx (Europe) and then elephants (Asia and Africa). In aggregate, the large cats (found on all continents except Australia and Antarctica) represented a major source of compensation funding.

A second notable finding is that the total payments for wildlife compensation in the publications we reviewed that included specific amounts approached a quarter of a billion U.S. dollars across a minimum of 138 different programs since 1980. These are almost certainly significant underestimates of the total number of programs and amount paid because numerous programs have not been the subject of papers or reports or made payment estimates public. This suggests investments in compensation may represent a substantial contribution to global investment in human–wildlife conflict mitigation.

The most common recommendation for improving compensation programs was to link payments to conflict-prevention measures. Making compensation conditional on adoption of preventative activities may encourage farmers to implement approaches to reduce the risk of future conflict (Boitani et al. 2010). This approach is widespread in Europe (Marino et al. 2016) and has been used in areas such as the Amboseli ecosystem in Kenya, where cattle are required to be enclosed in *bomas* at

night (Okello et al. 2014). Full compensation without requiring preventative measures may actually discourage investment in protection (Rondeau & Bulte 2007). This appears to have been the case in Norway, where compensation for sheep depredation by wolves was high but shepherds were reluctant to adopt measures to reduce losses (Linnell & Brosth 2003). One challenge of requiring preventative measures is that data on type and quality of husbandry practices may be absent (Fernández-Gil et al. 2016).

Our results suggest it is not uncommon for victims of human–wildlife conflict in some regions to wait months or years to receive payment. For example, a program in Kenya took an average of four years to pay claims (Sifuna 2005). The limited size of the sample reporting information on the timing of payment (about one-quarter of the schemes we identified) and the aggregated data may mask changes in administrative efficiency over time, but payment speed is clearly a challenge for some programs.

Our findings also shed new light on ongoing debates in the human–wildlife conflict literature about the effectiveness of compensation as a human–wildlife conflict mitigation tool. We hypothesize that at least some differences of opinion reflect a tendency of scholars not to differentiate between the process of compensation and the result of compensation. Criticism focused on process (e.g., compensation too slow) may be fundamentally different from praise focused on result (e.g., fewer retaliatory killings). Our results are informative in this regard: three-quarters of negative comments focused on process, whereas three-quarters of positive comments focused on result. Understanding these differences may have implications for conservation practice because concerns about management (process) may be comparatively easier to fix than concerns about conservation outcomes (results) because managers can improve inefficiencies more easily than they can address fundamental problems related to interactions between wildlife and people or even people and people (Redpath et al. 2015a). Our results thus also suggest a new framework for evaluating compensation programs. By more carefully differentiating and assessing the administration of compensation schemes separately from reductions in conflict and other conservation outcomes, more studies may move beyond relatively binary questions about whether compensation is or is not an effective and encourage assessments that better evaluate how strongly or weakly the compensation process is linked to outcomes. Finer-grained and more nuanced analyses will help differentiate the relative importance of ecological, economic, and social factors involved in human–wildlife conflict (Suryawanshi et al. 2013) and uncover underlying factors that may ultimately drive patterns of compensation (Fernández-Gil et al. 2016).

Compensation programs are valuable only if they actually reduce the frequency of conflict and mitigate the negative impacts of human–wildlife and human–human conflict (Nyhus et al. 2005). It is notable that <5% of papers defined success in existing programs. Those that did expressed success as reduced conflict (Rodricks 2010; Tombre et al. 2013), reduction in animal killing (Dickman et al. 2014; Okello et al. 2014), recovered wildlife populations (Klenke et al. 2013; Persson et al. 2015), less human injury (Anthony & Swemmer 2015), changes in local opinions or attitudes toward wildlife (Stone 2009), helping victims of wildlife damage (Madhusudan 2003), and improved relationships among stakeholders (Anthony & Swemmer 2015). Some authors simply proposed methods of measuring the success of a compensation program, such as recommending socially efficient outcomes or achieving goals in a cost-effective way based on economic measures (Dyar & Wagner 2003; Schwerdtner & Gruber 2007).

Debates over the effectiveness of compensation are further masked by lack of clarity over geographic, taxonomic, and sociodemographic differences. For example, in Europe, funding for compensation programs is often public and tends to be more stable, there is abundant experience, and thus relatively fewer fundamental disagreements over the role of compensation (Kaczensky et al. 2013). In other regions, funding may be more ephemeral if provided by nongovernmental organizations (Nemtzov 2003), and administration of programs may be more likely to face problems of corruption or other administrative inefficiencies (DeMotts & Hoon 2012). Compensation programs for livestock losses from predators such as lions (Hazzah et al. 2014) may address very different concerns over risk than those for agricultural damage by geese (Tombre et al. 2013). Furthermore, some assessments focused on the role of people (both in terms of administrative efficiency as well as social outcomes), whereas others focused on outcomes for wildlife. This is important because compensation programs may have unintended consequences, such as increasing inequality and social tension (Anyango-Van Zwieten et al. 2015). There are also theoretical arguments that compensation reduces wildlife populations by encouraging increased agricultural production and subsequent habitat loss (Rondeau & Bulte 2007).

Our methods, as with literature reviews generally, have several limitations. Our reliance on published scholarship and reports almost certainly underrepresents the prevalence of compensation programs in some regions and skews our results toward regions where English-language publications catalogued by academic search engines are more common and where government agencies and nongovernmental organizations have a tradition of reporting these data (Fourli 1999). We tested this limitation by exploring whether the paucity of compensation studies in Latin America was due to a lack of published studies or, alternatively, that studies were published in Spanish-language sources that did not appear in our searches. We uncovered few additional publications with our Spanish

search terms, suggesting language alone was not a primary driver of this trend, at least in Central and South America. Even some English-speaking regions, such as Australia, were notably underrepresented. Our reliance on scholarly search engines also underrepresented data from web pages, unpublished information, reports from nongovernmental and governmental organizations, and abstracts from professional meetings.

Additional sources of uncertainty were that it was difficult to differentiate regional and independent programs and that not all publications describing compensation programs reported payment amounts. We attempted to account for potential duplication and double counting, but our estimates may include duplications from different sources. Some publications focused on one or more species and may not have described the true extent of compensation payments made for other species covered. Furthermore, summarizing the amount paid may not accurately reflect the relative total purchasing power of these payments (e.g., a dollar of compensation may be much more valuable in some regions of Africa than in some regions of Europe) and underestimate the value of in-kind payments. Payment alone also does not represent the true cost of compensation programs such as overhead costs (Schwerdtner & Gruber 2007). Finally, the recommendations summarized in Table 2 were derived from the 288 papers included in this study, the authors of which may not be practitioners or compensation recipients (although sometimes authors were summarizing those perspectives). Nevertheless, our results provide a conservative minimum baseline for the number of programs and amount of compensation paid out and likely represent a reasonable proxy for the relative distribution and pattern of compensation programs globally.

Our results suggest there is a need to more methodically evaluate the effectiveness of compensation schemes. One approach may be to more precisely define success in terms of concrete process elements related to how programs are managed (e.g., time of payment, amount of payment) and concrete results, including both social outcomes (e.g., more positive attitudes or conservation behaviors among compensated victims of human–wildlife conflict) and wildlife conservation outcomes (e.g., fewer retaliatory killings of species of conservation concern). Relatively few studies or programs defined or measured clear conservation outcomes directly linked to compensation programs. More clarity in thinking about these linkages may provide additional opportunities for controlled experiments (Ring et al. 2013) and to apply adaptive management (Anthony & Swemmer 2015).

The human–wildlife compensation literature is replete with isolated case studies focused on individual protected areas or taxa. Further improvement in understanding of the strengths and weaknesses of compensation as a conflict-mitigation tool could come from more comparative analyses (Nyhus 2016). Notably, there is a need to expand understanding of the scope of compensation programs by examining underrepresented regions, particularly South America, Oceania, and parts of Africa and Asia, and taxa. More comparative and experimental studies that explicitly test variables hypothesized to influence compensation (e.g., amount and type of payment, time and method of payment, requirements associated with payment) and type of programs (e.g., insurance or performance payments) would help managers refine implementation of compensation programs.

Several research questions emerged from our study. Could more comparable metrics be developed to evaluate programs across regions and taxa (e.g., amount of payment as a proportion of crop or livestock value)? Could more transparent measures of conservation outcomes and measures of coexistence be developed (e.g., measures linking compensation to changes in frequency of retaliation, changes in abundance of wildlife of conservation concern, or changes in positive attitudes or interaction with wildlife managers)? Are relationships between payment and positive conservation behavior linear or are there thresholds below or above which changes occur? How does the risk of human injury or death affect the perceived effectiveness of compensation programs? Much of the compensation literature reflects the views of practitioners or scholars. There is a need for additional scholarship studying the views of compensation recipients and how their perspectives are similar to or different from practitioners.

The significant global investments in compensation and the growing number of studies examining compensation attest to the importance of compensation as a tool in the mitigation of human-wildlife conflict. Additional work is needed, however, to improve understanding of how the implementation of this tool can be refined and strengthened to achieve stronger conservation outcomes. Human-wildlife conflict will remain a key conservation challenge for the foreseeable future, and more nuanced evaluation of conflict prevention and mitigation approaches is one way to increase the likelihood of human-wildlife coexistence.

Acknowledgments

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Supporting Information

List of articles included in the data analysis (Appendix S1), negative and positive comments about compensation schemes made in the literature categorized as positive,

negative, results oriented, or process oriented (Appendix S2), and suggestions for improving the effectiveness of compensation made by authors and categorized by the core elements hypothesized in Nyhus et al. (2003) (Appendix S3) 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.

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