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Conservation conflict hotspots: Mapping impacts, risk perception and tolerance for sustainable conservation management

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Global processes manifesting as activities in local places have led to an increase in documented conservation conflicts. Conservation conflicts are sometimes labelled human-wildlife conflict, focusing only on the direct negative impact of species (usually wildlife) on humans or vice versa. However, many authors now recognize that conservation conflicts arise between people with diverse views, when one party acts against the interests of another. They are thus human-human conflicts and not merely an impact on or from conservation. Conflict is not always directly correlated with impact because perceptions of risk, levels of tolerance and conservation values influence human responses. This review aims to define the concept of 'conservation conflict hotspots' and explore its practical applications in conservation. We propose that the interaction of impact, risk perception, level of tolerance in a context of conservation values can be mapped at a local scale, with spatial visualization assisting the prediction, understanding and management of such hotspots. The term conservation value incorporates measures of indigeneity, endemicity and demography along with emotional or cultural attachment to species or places. The umbrella terms of risk perception and tolerance capture many of the aspects of attitude, values and individual demographics that can influence people's actions, enabling contextualization of relevant social factors at local scales. Spatially mapped layers enable us to plan and target conservation efforts towards human as well as ecological factors. The concept of 'conservation conflict hotspot' emphasizes the need for transdisciplinary research to understand underlying drivers of conflict and for dialogical and peace-building approaches to facilitate trust and cooperation amongst actors. We can thus address conflicts and achieve sustainable outcomes.

KEYWORDS
human-wildlife interaction, attitude, conservation values, sustainable development, conflict transformation

Introduction

Interactions between humans and wild animals are increasing globally due to land-use change and climate change, amongst other issues (Frank et al., 2019). This trend has caused many researchers to address what they call "*human-wildlife conflict*", focusing mostly on impacts defined as "circumstances where people, consciously or unconsciously, negatively impact biodiversity, or alternatively, where wildlife or other aspects of biodiversity negatively impact the wellbeing or livelihoods of people" (Young et al., 2010, p. 3974). A few 'conflict hotspot' studies have predicted and mapped potential impacts, such as future depredation (Wilson et al., 2005; Wilson et al., 2015; Chen et al., 2016; Broekhuis et al., 2017). However, some researchers have focused on wider biodiversity conservation concerns and on the human dimensions of such interactions. They have acknowledged that conservation conflict arises when competition over some aspect of conservation occurs between different interested parties, and one party pursues their interests at another's expense (Marshall et al., 2007; White et al., 2009; Redpath et al., 2015). Crucially, it is thus not only attitudes but enacted behaviors that actually cause conflict. We develop this latter perspective here, recognizing that underlying social parameters, as well as impacts, will influence the form of and solutions to conflict as well as conservation outcomes and social cohesion. The aim of this paper, through an analysis of existing literature, is to define and elucidate a wider concept of 'conservation conflict hotspots' that includes human dimensions of conservation conflicts, beyond merely the impacts of wildlife on humans or humans on wildlife; that articulates clusters of human dimensions around risk perception and tolerance; and that demonstrates the spatial nature of multi-dimensional conflict potential and intensity.

The notion of 'conflict hotspot' in conservation was first defined by Wilson et al. 2005 (p. 120), as "discrete areas that were characterized by concentrations of conflicts", referring to impacts of wildlife on humans or their activities. Such hotspots often focused on (de)predation by carnivores. Predation risk is known to be spatially unevenly distributed: habitat and landscape characteristics, as well as anthropogenic factors, can influence the odds of impact and determine the existence of 'predation hotspots' (Miller, 2015; Broekhuis et al., 2017). Spatial predation risk models that correlate landscape attributes with the occurrence of wildlife impacts on human activities (Abade et al., 2014; Miller, 2015) are then used to focus prevention efforts and mitigation measures towards high-risk areas (Zanin et al., 2015). However, focusing only on impacts such as predation on livestock has led to important misconceptions about conservation conflict "(A) that the level of wildlife damage is directly related to the level of conflict engendered; (B) that the level of conflict elicits a proportionate response; (C) that altering the response to conflicts will have proportionate conservation effects" (Dickman, 2010, p. 459). These assumptions have been demonstrated to be flawed, because the implementation of strategies to reduce impacts has rarely led to long-term conflict resolution (Dickman, 2010; Madden and McQuinn, 2014). Furthermore, conservation conflicts can be very intense even with little biodiversity impact (Young et al., 2010). Conservation conflicts are thus more complex than the sum of impacts; they are embedded in specific socio-economic contexts (Young et al., 2010; Kansky and Knight, 2014) and 'conservation conflict hotspots' will stem not only from impacts but also from clusters of spatially distributed human attitudes and behaviors.

Conservation practice is an inherently social phenomenon and a product of human behavior (Mascia et al., 2003), hence social aspects should be considered when developing tools that direct conservation efforts. Recent reviews have detailed how we could model interactions between conservation indicators for socio-ecological systems (Williamson et al., 2018) and human-wildlife coexistence (Carter et al., 2020). It is also important to recognize the spatial distribution of human parameters (such as attitudes) for theoretical understanding; to develop practical tools that can be applied locally; and to enable prioritization of interventions. Attitudes are seldom consistent across space and areas of concentrated negative attitudes against species can lead to higher human-caused mortality of wildlife, which creates wildlife population sinks that adversely affect their persistence (Woodroffe and Ginsberg, 1998; Liu et al., 2011). Recent research has shown that mapping attitudes towards wildlife can highlight potential clusters of negative attitudes (White et al., 2009; Carter et al., 2014; Piédallu et al., 2016; Behr et al., 2017; Struebig et al., 2018). We propose here to theorize the concept of 'conservation conflict hotspot' by unpacking relevant aspects of attitudes and subsequent behaviors where at least one party acts against the interests of another. We highlight the importance of risk perception, tolerance, and conservation value, and explore the consequences of such parameters along with impacts in a spatial context.

It is a complex matter to identify where, when, and how conservation conflicts may be triggered and to what extent they may provoke negative conservation and societal outcomes, from mild activities to extreme violence. We suggest that risk perception and tolerance are effective individual parameters to combine with impact measures to predict conservation conflict spatially and identify conservation conflict hotspots that demand priority intervention. People's attitudes and behaviors depend on how they perceive the risk of being affected (Gore et al., 2009; Carter et al., 2012) and their level of tolerance to it (Bruskotter and Wilson, 2014; Browne-Nuñez et al., 2015; Bruskotter et al., 2015; Kansky et al., 2016). Both parameters are subjective, value-laden and intuitive judgments that influence behaviors and behavioral intentions (O'Connor et al., 1999; Kansky et al., 2014). Either escalating risk perception or reduced tolerance can influence the tipping point that triggers people's actions within a conflict (Gore et al., 2009; Bruskotter and Wilson, 2014; Struebig et al., 2018). According to our definition of conservation conflict (Marshall et al., 2007; White et al., 2009; Young et al., 2010), a conflict between people emerges only if an action is taken by one party against the interests of at least one other party. Such actions can range from signing a petition, to demonstrations, to retaliatory killing of wildlife, or even violence against the agencies responsible for managing wildlife (Bruskotter and Fulton, 2012). For instance, retaliatory killing itself creates impact but the conflict occurs if groups such as conservationists, indigenous people or rewilding advocates are against such killing, expressing contrasting conservation values. Conservation values are broadly defined here as any form of importance (e.g. ecological, economic or socio-cultural) assigned to a species or habitat (Laurila-Pant et al., 2015). They result, for example, in the creation of protected areas, species protection status, or a particular societal attachment to species. Therefore, we define a conservation conflict hotspot as being a spatially explicit area, where a group of actors acts against the interests of at least one other group, because of the interaction of impacts of conservation on humans or vice versa, perceived risk of these impacts, and levels of tolerance towards them.

We thus move beyond the notion of conflict hotspot defined merely by impact (Wilson et al., 2005; Wilson et al., 2015; Chen et al., 2016; Broekhuis et al., 2017) to acknowledge that human action affecting others with divergent views and interests is one of the fundamental defining features (Marshall et al., 2007). While we recognize that other aspects of the wider context in which a situation develops also influence the potential occurrence of conflict, we examine human phenomena here to better understand this aspect of conflict hotspots. We will now discuss the context of conservation values and the likely roles of impacts, risk perception, and tolerance in the emergence of conservation conflicts. We then explore the potential to map those notions to spatially predict conservation conflict hotspots. Finally, we suggest theoretical approaches and practical management strategies to cool these hotspots.

Conservation values and conflict

We identify a primary factor that will influence the potential for and intensity of conservation conflicts: conservation values. Whilst we later focus on the spatial representation of the factors influencing the likelihood of actors taking action against the interests of another party (the protagonists), the sensitivity of the party (or parties) against whom they are acting is also important. We are not initiating a novel debate around the value of nature here (see Rawluk et al., 2019), but we consider conservation values to be any need, concern, or interest (Laurila-Pant et al., 2015) that a group puts forward for the conservation of biodiversity. One criticism of adopting the notion of conservation values is that they are human-centered and refer mainly to instrumental values (and possibly relational values), ignoring the intrinsic value of biodiversity (Arias-Arévalo et al., 2017; Batavia and Nelson, 2017). However, our definition of conservation conflict hotspot emphasizes human-human conflicts, and we are interested in how conservation values are transformed into sensitivity, a form of tolerance that changes the threshold above which an action from one party is perceived to be against the interests of another party. For example, where conservation values are high, such as in a protected area or for an endangered species, a small action can create an intense conflict.

The term conservation values encompasses a number of aspects in relation to species or habitats, including scientific parameters such as distribution (e.g. endemicity) and population size, and threat assessment parameters (e.g. endangered), and functional ecosystem roles. However, 'values' also includes economic values, socio-cultural importance, and emotional attachment (see Jepson and Canney, 2003). Emotional value can be seen in the widespread public support for the conservation of iconic species such as polar bears and tigers (Albert et al., 2018), but also in a 'relational ontology' with deep cultural and spiritual connections between indigenous communities and nature (Datta, 2015). Higher conservation values are more likely to lead to conservation conflicts since small actions are more likely to be perceived to be against conservation interests.

It can be difficult to spatially represent conservation values, because they are driven by national and global as well as local factors. At local levels, ecological, economic, socio-cultural and attachment indicators can be identified for representation of different values, for example, protected area status or presence of an endangered species. However, in this paper, we suggest that conservation value is integrated within the parameters of risk perception and tolerance as discussed below. Greater conservation value will increase perception of risk and reduce tolerance for actions taken against conservation interests.

Risk perception and tolerance in relation to conservation conflicts

Risk perception is key for assessing the underlying factors affecting conflicts, but there is often a discrepancy between the perception of risk, the actual degree of risk, and the response to risk (Slovic, 1987; Gore et al., 2009). Early approaches argued that risk perception was a rational reaction due to a lack of information to appreciate true risk. However, we now know that quantifying and reducing true risk and subsequently disseminating information about this reduction can have limited success in preventing conservation conflict (Madden and McQuinn, 2014). Instead, it is important to consider both cognitive risk (the perceived probabilities of suffering harm or loss involving uncertain hazards (Renn, 1992) and affective risk perception (dread or worry about potential hazards). These two types of risk perception are not necessarily correlated (Sjöberg, 1998). For example, communities that are more directly dependent on forest resources will perceive an elevated cognitive risk toward tigers that inhabit forests (Carter et al., 2012). Also, recolonization of large carnivores in areas where people are unfamiliar with the species in question can lead to increased affective risk perception (Behr et al., 2017). Both examples show how negative perception of risk can be spatially clustered and be a cause of people entering into conservation conflict with other people, by taking action against their interests in relation to conservation.

Tolerance is another key ingredient required to understand behaviors in relation to conservation. In conservation, tolerance has been assessed to measure people's capacity to coexist with large species (Treves, 2009; Treves and Martin, 2011; Bruskotter and Fulton, 2012; Kansky et al., 2014). Definitions of tolerance have spanned from a lack of poaching despite damages inflicted by a species (behavioral), to individual-level judgments of predators (attitudinal) (Treves and Bruskotter, 2014). In our concept of 'conservation conflict hotspot', tolerance can inform both the breaking point when people cease their passive acceptance and the decision-making process that causes people to act against the interests of other parties (see 'intolerance' in Bruskotter et al., 2015). Resentment against policies that limit communities' access to resources or a lack of decision-making authority in some marginalized communities can result in areas with a lower tolerance level (Carter et al., 2020). On the other hand, the existence of clusters of positive tolerance toward wildlife (see cultural tolerance; Gebresenbet et al., 2018; Brenner and Metcalf, 2020) can explain better species persistence in some areas. For example, tolerance of Sumatran tigers by Kerincinese and Minangkabau people in Indonesia is explained by spiritual belief systems, such as that ancestral souls are embodied within tigers (Struebig et al., 2018).

The purpose of this paper is not to propose new frameworks and measurements regarding risk perception and tolerance. Several authors have framed the underlying drivers or developed assessment tools and conceptual models for complex decision-making (Bruskotter and Fulton, 2012; Carter et al., 2012; Bruskotter and Wilson, 2014; Kansky and Knight, 2014), and many variables (summarized in Table 1) are known to influence tolerance or risk perception. For our paper, these concepts are useful precisely because they can be proposed here as overarching umbrella terms that cover combinations of social and behavioral variables (e.g. more than 27 sub-categories of variables in Kansky and Knight, 2014). Our adoption of 'risk perception' and 'tolerance' thus allows us to broadly capture many of the aspects of values, attitudes and demographic variables that can influence people's actions. In fact, the framings of risk perception and tolerance share certain variables, such as 'introduced benefits', 'trust' or 'personal previous experience' (Carter et al., 2012; Kansky and Knight, 2014; Kansky et al., 2016). However, risk perception and tolerance cannot be used interchangeably (see Inskip et al., 2013), because they only share some underlying variables and they can manifest independently. For example, people may perceive a high risk but maintain a high level of tolerance (Inskip et al., 2013). Both umbrella terms are important to understand how people process information using analytical and experiential systems: perception of risk can occur before experience of impact, and has anticipatory quality, whereas tolerance tends to be assessed after interaction with biodiversity, possibly with experience of impact. Their value is in illustrating a simple theoretical model that emphasizes social aspects of conservation conflicts while their practical utility enables us to assess people's propensity to act against others within a conflict in a particular space.

Modeling and mapping conservation conflict to predict conservation conflict hotspots

Impact, risk perception, tolerance and conservation values may be related but are not always correlated and can have independent influences on attitudes and behaviors. For example, even when impact (e.g. depredation on livestock by a large carnivore) is high, if local actors perceive the risk as low and/or are highly tolerant towards the species, they are unlikely to act against the interests of conservation by killing said species in revenge. Conversely, a high perception of risk and low tolerance for even minor impacts could lead to retaliatory kills that are contrary to the interests of others (e.g. conservation groups) and thus cause conflict. We illustrate this hypothetical framework in Figure 1, visually demonstrating how impacts comprise only part of the picture and that social factors are crucial in determining the incidence and intensity of conservation conflict.

An important tool for both conservation and social outcomes would be to predict where and when intense conservation conflicts might occur. Evaluating the spatial distribution of the social determinants of such conflicts has been largely unexplored, but recent developments of socio-ecological models have demonstrated novel ways to spatially integrate social and ecological factors to better inform decision making and improve outcomes for both biodiversity and humans in shared landscapes (Lischka et al., 2018). For example, Carter et al. (2014) found out that people with less formal education and from marginalized ethnic groups were more likely to live in the western part of the study area in China, where negative attitudes toward tigers were more prevalent. Attitudes toward brown bears in the French Pyrenees also differed spatially, with one county showing negative attitudes

TABLE 1 Factors used to assess the potential of conservation conflict: perception of risk, tolerance, impact, and the related variables commonly measured that have been shown to influence them.

Factor	Variables commonly measured to assess their influence on the factor	References
Perception of risk	Socio-economic status Gender Context Certainty Seriousness of impact Volition Dread Perception of frequency Responsiveness Source of the risk (natural or not) Rational trust Control Accountability Value orientation/Personal value Beliefs in relation to species	Flynn et al., 1994; Riley and Decker, 2000; Slimak and Dietz, 2006; Earle and Siegrist, 2008; Gore et al., 2009; Carter et al., 2012; Gore and Kahler, 2012; Muter et al., 2013; Sponarski et al., 2016
Tolerance	Socio-economic status Beliefs Ethnicity Social norm/Attitude Experience Values Empathy Governance arrangement Personal norms Wildlife value orientation Knowledge Dependency Social trust Species characteristics Locus of control	Kansky et al., 2014; Karlsson and Sjöström, 2011; Slagle et al., 2012; Bruskotter and Wilson, 2014; Kansky and Knight, 2014; Browne-Nuñez et al., 2015; Bruskotter et al., 2015; Kansky et al., 2016; Sponarski et al., 2016; Struebig et al., 2018
Impact	Abundance of natural habitat Key landscape features (e.g. water points, large trees) Landscape fragmentation Prey abundance Infrastructure (e.g. roads, settlement) Human activity (e.g., land-use, hunting) Livestock species Livestock management practices	Dar et al., 2009; Thorn et al., 2012; De Angelo et al., 2013; Behdarvand et al., 2014; Soh et al., 2014; Olsoy et al., 2016

while two others indicated positive attitudes (Piédallu et al., 2016). Finally, Struebig et al. (2018) found targeting villages ranked as high priority in their socio-ecological projections that included tolerance measures for preventive intervention in could have prevented up to 51% of tiger attacks on livestock and people and potentially saved 15 tigers.

We thus introduce a simple analytical model to develop a spatially explicit approach to predict the potential for a 'conservation conflict hotspot' by integrating spatial data on tolerance and perception of risk in the context of conservation values (see an example using hypothetical data in Figure 2). We include conservation impacts on humans, or vice versa, in our model because impacts can influence tolerance and risk perception and thus behaviors and hence specific technical interventions to reduce impacts can in some cases mitigate conflict. Each layer is built from variables that will differ according to the conservation issue at play and the context. For instance, the impact layer might include data such as forest cover within a given radius or distance to human settlement; the risk perception layer, data on how people control the impact or perceive others to be able to control it; and the tolerance layer, data on people's values or previous experience with wildlife and conservation authorities (See Table 1 for more examples). While ours is not a turnkey analytical model, Figure 2 shows that incorporating information about risk perception and tolerance of impacts changes the potential intensity and location of conflicts over conservation. We advocate for an alternative to incomplete framings of 'conflict hotspot' assessed only by

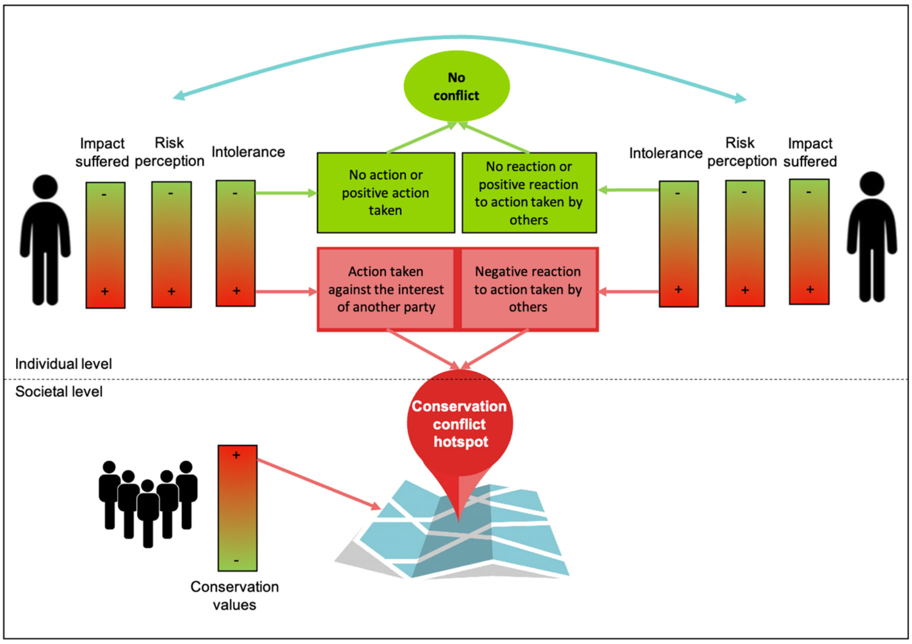

FIGURE 1
Proposed model framework for conservation conflict hotspots. At the individual level, impact suffered, risk perception and (in)tolerance drive people's decision making to act or not against the interest of another party and to react or not to this action, leading potentially to conservation conflict. The blue arrow indicates a feedback effect of the relationship between the two parties on the factors of suffered impact, risk perception and (in)tolerance. (For simplicity's sake, we represent here intolerance instead of tolerance) At the societal level, the collectivity drives conservation values; if these conservation values are high, there is increased potential for a conservation conflict to arise.

impacts. Instead, we propose a more precise concept of 'conservation conflict hotspot' where impact, risk perception, and tolerance layers are derived from attributes such as those presented in Table 1.

We are aware that we only predict and map the *potential* for conservation conflict hotspots. However, this knowledge can inform conservation strategies. For example, when identifying suitable future habitat for wolves in Switzerland, the incorporation of social data into a habitat suitability model led to a large reduction in the area available for wolf that was both ecologically compatible and socially acceptable (Behr et al., 2017). The human dimension captured in their study explains why 'suitable' wolf habitat predicted by the original habitat suitability model has not yet been occupied, despite 20 years of wolf presence in the area with high dispersal and recolonization potential. Whilst future wolf recolonization might influence future tolerance and risk perception, the integrative approach in this area can predict zones of potential future conflict (Behr et al., 2017). Integrating ecological and social data into socio-ecological models resulted in predictions of tolerance that were 32 times better than models based on social predictors alone in a study of conflict over tigers (Struebig et al., 2018). Explicitly incorporating social factors into spatial analysis would allow practitioners to identify locations where coexistence strategies are both biologically critical and socially feasible. Moreover, broader recognition of the social factors that inhibit or promote conservation may help to identify a more diverse suite of targeted interventions and improve conservation priority-setting to transform conservation conflict into an opportunity for socially just and environmentally efficient transformation.

Managing conservation conflict hotspots

Integrating social data in spatial visualization has been used in the past mostly to prioritize conservation intervention, to efficiently and effectively allocate limited resources such as money and personnel (Carter et al., 2020). Such an approach was used by Struebig et al. (2018) who ranked villages according to their likelihood of retaliatory killing of tigers. However, predicting spatial clusters of positive or negative social parameters can be useful, along with ecological and impact data, for additional purposes. For example, reintroductions of controversial, high conservation-value species are likely to increase the intensity of the conflict in areas with low tolerance or high-risk perception, whereas areas with higher tolerance or lower risk perception may be more suitable (Behr et al., 2017). It is also important to understand the detail of

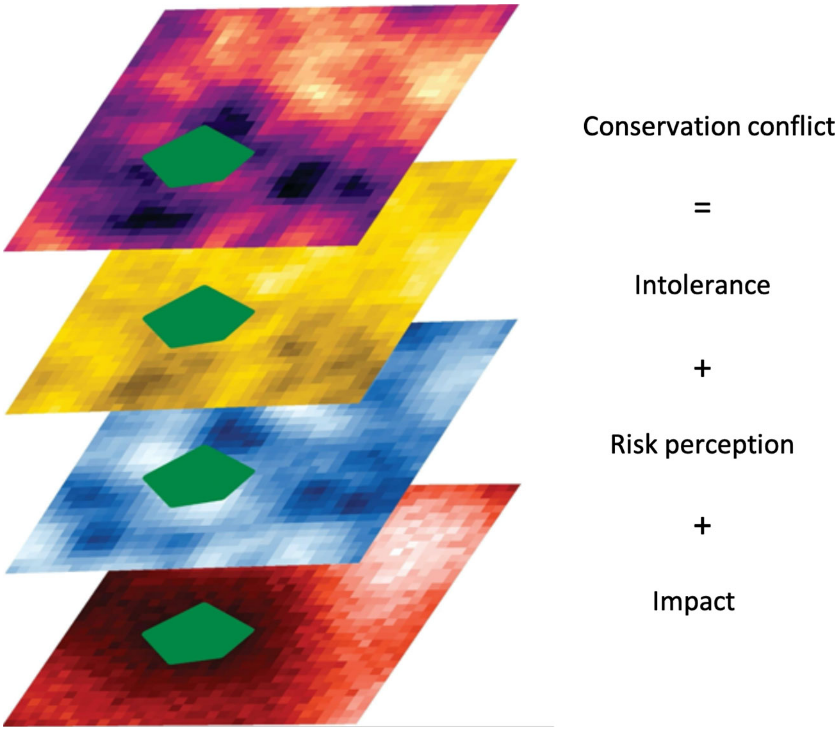

FIGURE 2
Modeling layers for impact (damage caused by or on biodiversity), risk perception and intolerance enable us to produce a visual map of conservation conflict. The darker the color on the top composite visualization layer, the greater the potential of conservation conflict, therefore defining a conservation conflict hotspot. This map is based on hypothetical data, where the green area represents a potential protected area to contextualize the example; although not all conflicts occur around protected areas, surrounding zones can be areas of contention.

predicted social parameters. For instance, low tolerance due to resentment against conservation managers requires different conservation management strategies than those that target high risk perceptions in an area.

A strength of our approach is thus to be able to dissect the different factors involved in predicting potential conservation conflict hotspots. Whilst impact alone will not necessarily lead to conservation conflict and poor conservation and social outcomes, we expect that technical efforts to reduce impacts of wildlife or other biodiversity aspects will still form an element of conservation strategies in an area. From experience, we also know that whilst there may be deeper underlying social aspects, a claim from the local community to protect their flock or herd is often one of the first points of dialogue to emerge. Predictive or actual mapping of impacts such as predation allows for locally focused technical effort and implementation of actions such as compensation, preventative measures such as keeping livestock animals in corrals at night, dogs, chili fences (e.g. Chang'a et al., 2016) or through zoning measures to reduce interactions between wildlife and human activities (Mech, 2017). Those measures can then in turn influence people's level of tolerance or perception of risk. Both parameters were positively affected in the case of wolves in Sweden or tigers in China, where subsidized fencing positively affected people's risk perception and tolerance (Carter et al., 2014; Johansson et al., 2016).

Addressing demands to limit impacts should not, however, deliver only technical approaches and fail to address more profound concerns of local people in relation to tolerance or risk perception. Spatial variation in risk perception and tolerance can help us understand how conservation conflicts are influenced by issues such as unequal power relations or poor knowledge (see Margulies and Karanth, 2018). For example, the "fear factor" plays a major role in the opposition to the wolf in Switzerland, where people hold false beliefs about the dangerous behavior of wolves toward people and livestock (Behr et al., 2017). This realization prompts us to seek management solutions such as public awareness. However, other studies show that community fears are not only built at an individual level but also depend on the trust that local people have in authorities (Johansson et al., 2016). Therefore, it is important to distinguish between rational trust, which is how people perceive an institution's ability to perform its functions (e.g. protecting them from wildlife), and relational trust, which is about valuing shared values and goals (Stern, 2008; for other dimensions of trust, see Earle, 2010; Stern and Coleman, 2015). Management actions aimed at rational trust might include documenting and publicizing past and ongoing management successes, whereas building relational trust requires broader activities. These activities could include, for example, collaborative engagement and improving transparency of key operations, as well as integrating relevant knowledge into deliberations and decisions (Sjölander-Lindqvist et al., 2015; Young et al., 2016). Furthermore, spatial information can provide important clues about potential divisions among the population, such as the urban/rural divide in the fear of wolf in Sweden (Johansson et al., 2016).

Finally, it is important to analyze the spatial variability of tolerance as it gives us an entry point to better understand how cultural, economic, or political variables influence conservation conflict. For example, higher levels of cultural tolerance, such as those reported above in Sumatra, Indonesia, have been shown to allow greater persistence of carnivore species in diverse regions (Karanth et al., 2010; Gebresenbet et al., 2018; Struebig et al., 2018). However, this cultural tolerance can be eroded by changing economic and management situations. For example, in Bandipur in India, wildlife attack dynamics have changed from attacks "inside the forest" to attacks closer to the village, due to shifting economic arrangements, altered livestock demographics, and resultant modified grazing practices (Margulies and Karanth, 2018). While the number of attacks remained almost the same, where attacks took place had a direct influence on how people tolerated wildlife as those new attacks "were interpreted by villagers as a breach of an unwritten social contract between themselves and wild animals" (Margulies and Karanth, 2018, p. 7). Tolerance can also be shaped by social status and position. In Chitwan, China, Carter et al. (2014) found that people from marginalized groups including lower castes and less educated individuals expressed more negative attitudes toward tigers. The spatial visualization showed that these groups are concentrated in a region where they do not have access to or cannot fully take advantage of schools, markets, and off-farm employment opportunities that are concentrated in the city. Clusters of positive attitudes were associated with higher castes that enjoyed more socioeconomic and political power, had more access to the economic benefits of wildlife tourism, and where tiger management was more intensive (Carter et al., 2014). Management solutions should thus focus both on and beyond technical aspects of the conflict. Conservation managers must recognize structural inequities and seek to counteract them with environmental justice. When possible, they should address the social roots of conflict using approaches such as dialogic, inclusive, participatory approaches to finding common ground (Lecuyer et al., 2018a), community-based natural resource management (Dressler et al., 2010) or conflict transformation (Madden and McQuinn, 2014; Rodríguez and Inturias, 2018; Zimmermann et al., 2020).

The investigation of 'conservation conflict hotspots' as described here can thus be used for conservation management in different ways. First, by using the cumulative power of the different parameters (impacts, risk perception and tolerance), mapping can predict areas with high potential for conflict. We propose that the co-occurrence of high impacts of conservation on humans or vice versa, low tolerance and high perception of risk will predict conservation conflict hotspots. Conservation management actions addressing these three factors will reduce conflict and enhance conservation and possibly social outcomes. Second, the parameter layers can also be used separately to inform management action, depending on the organization's interest and focus in the region, such as whether their goals or funding are directed at technical solutions or developing participative programs. In addition, understanding the dynamics between the three layers can inform our conceptual understanding of the deeper causes and diverse forms of conservation conflicts. For instance, tensions between local people and conservation actors at sites of impact may stem from a lack of trust in state actors rooted in power imbalances and historical injustices.

Challenges and future research

There are considerable challenges to modeling and mapping conservation conflict hotspots (e.g. White et al., 2009) but much progress has been made toward developing spatially explicit analytical models (Williamson et al., 2018). Implementation of our concept requires effective measurement of tolerance and perception of risk. Some factors are more important than others in determining tolerance and the way some research is framed may prevent us from understanding the drivers of tolerance (Kansky et al., 2014). Besides, tolerance is highly contextual, and it is difficult to find comparable variables to measure in different social and cultural contexts (Zimmermann et al., 2021). We suggest that understanding of particular conservation conflict hotspots might begin with a qualitative phase to explore how people define and determine tolerance and perception of risk. In addition, whilst the scientific parameters of conservation value have been much debated, we have paid less attention to emotional attachment and cultural values of conservation (Arias-Arévalo et al., 2017; Rawluk et al., 2019).

Whilst we can begin to understand how these variables may occur and can be represented, additional data collection will be required to develop detailed predictions or management tools for a particular region. Such data collection is resource and time-intensive, but there are some ways to overcome these difficulties (also see de Barros Ferraz et al., 2022). First, we propose to increase the trend toward more social scientists, community commissioners, and dedicated staff in conservation organizations. Interdisciplinarity and participatory interdisciplinarity (O'Brien et al., 2013) can enable ecologists and conservation biologists to collaborate with social scientists as well as local managers and authorities to share and combine different datasets (see also Marchini et al., 2021). Second, data collection can be integrated into a process to promote common ground consolidation (Lecuyer et al., 2018a) or dialogic decision-making. For example, participatory risk-mapping (see Smith et al., 2000) both engages local actors and generates relevant data. Third, detailed research projects at specific sites (e.g., Lecuyer et al., 2018a; Lecuyer et al., 2018b; Lecuyer et al., 2019) can be used to generate guidelines that can be adapted in other local contexts. Of course, models and maps will only be as good as the data and assumptions that support them, and data collection is a learning process that enables us to better understand the variables that underpin conservation conflicts. These changes will require a shift in the goals and expectations of funders, directorates, and agencies as well as new organizational and cross-institutional partnerships. However, even without detailed data collection, we propose that recognition of the conceptual model behind this spatial mapping process will alter conservation priorities. A holistic scan of the area with a transdisciplinary team including practitioners with local knowledge will potentially shift regional conservation focus beyond technical to systemic.

An additional challenge is scale, both spatial and temporal; conflict processes can unfold chronically and at multiple scales. Our approach emphasizes human interactions that occur in local contexts, and we consider tolerance, for example, at the community level. Although working at a small scale helps to circumvent the risk of flawed inference if spatial variation is ignored, even at such local levels, community heterogeneity could mask existing conflict potential (Sponarski et al., 2013). Attitudes are very sensitive to extreme values, and individuals who hold very strong but opposing opinions may be concealed through a focus on average values. Heterogeneity might be addressed through mapping of different groups of actors. For example, women often express higher levels of perceived risk (Carter et al., 2014), obscuring the potential difference with perceived risk among men at the community level. It would be possible then to separate men and women in the spatial analysis to see if spatial patterns of perceived risk appeared differently given a gendered use of space. Finally, social parameters such as tolerance may change over time, for example, following the introduction of new regulations or as development or cultural context changes. Conflict transformation approaches allow us to see conservation conflicts as a long-term process with episodes of conflict. They enable us to recognize and attempt to address deeper incompatibilities or injustices locally, along with the negative conservation outcomes accruing from conservation conflicts (Rodríguez and Inturias, 2018; Zimmermann et al., 2021).

In addition, external drivers may influence the factors involved in conservation conflicts. Decisions on the conservation status of a species, for example, do not occur at the local scale. Local risk perception and decision-making can be affected by global trends. For example, Struebig et al. (2018) correlated the recent spike of tiger poaching in their study with tiger skin prices and the state of the Indonesian economy. We recognize increasing pressures on biodiversity with human population growth and consumption in many areas [United Nations (UN), 2015], and we acknowledge the efforts of individuals and communities seeking to eke out a living within difficult climatic, minority and institutional settings. Whilst the wider context might influence the occurrence of conservation conflicts, we propose to map conservation conflict hotspots at a local scale to enable action beginning at the community level, as higher-level transformational changes can follow bottom-up approaches (Rodríguez and Inturias, 2018). Notwithstanding the potential challenges associated with mapping conservation conflict hotspots, we believe that this new paradigm has great potential to influence future research efforts and conservation thinking as well as management actions.

Future research should therefore involve defining the variables to include in each layer and how to adapt them to different contexts and scales. More targeted future research will also help to achieve a better understanding of the relationships between the layers of our model, i.e. impact, tolerance and risk perception. To test our proposed model of conservation conflict hotspots, future research should also collect information relative to conservation conflicts prior to extreme actions such as retaliatory killings, such as vocalized dissent and threats of conflict actions. While we focus here on negative aspects of conservation conflict, future research could also assess the positive side of these interactions and measure people's willingness to coexist with wildlife and engage in conservation stewardship (e.g. participating in a conservation program) (Bruskotter and Fulton, 2012; Bhatia et al., 2020; Brenner and Metcalf, 2020). This would allow integration of a continuum of potential behaviors that better embody the complex nature of human-wildlife interactions, moving away of the dualistic model of conflict or coexistence (Hill, 2021). Finally, while we have drawn primarily on literature regarding wildlife conservation, and more specifically carnivores, conservation conflicts encompass many other issues related to biodiversity, such as sustainable forest management or fisheries. Even if the nature of the parameters used to characterize the layers might differ with study context, we believe that including social parameters to understand the spatial distribution of such conflict will still be highly valuable.

Conclusion

Conservation is subject to conflict where actors have diverse views and act against the interest of other actors. There have been calls to properly address conservation conflicts (Peterson et al., 2010), but researchers still use the word 'conflict' when focusing only on conservation impacts on humans (e.g. Chen et al., 2016; Broekhuis et al., 2017). We have shown here that social factors strongly influence decision-making to act against other parties in relation to conservation, and thereby trigger conflict. We emphasize the definition of conservation conflict as being human-human conflict and we offer new insights for sustainable management approaches. For example, we propose that even if impacts cannot be eliminated or reduced in conservation conflicts, people may cease to act against the interests of others if risk perception or tolerance are altered. We agree that scale and external influences are also important challenges. We do not advocate that merely identifying conservation conflict hotspots will be sufficient to resolve a conflict. Conservation managers and those with development intentions will still have to develop actions and tools that will support stronger relationships and understanding among actors. However, an emphasis on such approaches will offer wider and longer-term benefits than technical solutions that only reduce impacts. There is a need for a paradigm change in conservation in which we embrace the reality that conservation is a human quest that is dependent on enabling social justice as well as ecological integrity (Vucetich et al., 2018). We propose that this conceptualization of conservation conflict hotspots will enable policymakers and practitioners, governments and civil society, conservationists, and activists for justice, to better understand and develop sustainable management strategies for the collaborative, dialogical pursuit of both ecological integrity and human development at local scales to match global aspirations.

Author contributions

LL, SC, BS, and RW contributed to conception and design of the study. LL wrote the first draft of the manuscript. SC, BS, and RW wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Abade, L., Macdonald, D. W., and Dickman, A. J. (2014). Assessing the relative importance of landscape and husbandry factors in determining large carnivore depredation risk in tanzania's ruaha landscape. *Biol. Conserv.* 180, 241–248. doi: 10.1016/j.biocon.2014.10.005

Albert, C., Luque, G. M., and Courchamp, F. (2018). The twenty most charismatic species. *PloS One* 13 (7), e0199149. doi: 10.1371/journal.pone.0199149

Arias-Arévalo, P., Martín-López, B., and Gómez-Baggethun, E. (2017). Exploring intrinsic, instrumental, and relational values for sustainable management of social-ecological systems. *Ecol. Soc.* 22 (4), 43. doi: 10.5751/ES-09812-220443

Batavia, C., and Nelson, M. P. (2017). For goodness sake! What is intrinsic value and why should we care? *Biol. Conserv.* 209, 366–376. doi: 10.1016/j.biocon.2017.03.003

Behdarvand, N., Kaboli, M., Ahmadi, M., Nourani, E., Mahini, A. S., and Aghbolaghi, M. A. (2014). Spatial risk model and mitigation implications for wolf–human conflict in a highly modified agroecosystem in western Iran. *Biol. Conserv.* 177, 156–164. doi: 10.1016/j.biocon.2014.06.024

Behr, D. M., Ozgul, A., and Cozzi, G. (2017). Combining human acceptance and habitat suitability in a unified socio-ecological suitability model: A case study of the wolf in Switzerland. *J. Appl. Ecol.* 54 (6), 1919–1929. doi: 10.1111/1365-2664.12880

Bhatia, S., Redpath, S. M., Suryawanshi, K., and Mishra, C. (2020). Beyond conflict: exploring the spectrum of human–wildlife interactions and their underlying mechanisms. *Oryx* 54 (5), 621–628. doi: 10.1017/S003060531800159X

Brenner, L. J., and Metcalf, E. C. (2020). Beyond the tolerance/intolerance dichotomy: Incorporating attitudes and acceptability into a robust definition of social tolerance of wildlife. *Hum. Dimensions Wildlife* 25 (3), 259–267. doi: 10.1080/10871209.2019.1702741

Broekhuis, F., Cushman, S. A., and Elliot, N. B. (2017). Identification of human–carnivore conflict hotspots to prioritize mitigation efforts. *Ecol. Evol.* 7 (24), 10630–10639. doi: 10.1002/ece3.3565

Browne-Nuñez, C., Treves, A., MacFarland, D., Voyles, Z., and Turng, C. (2015). Tolerance of wolves in Wisconsin: A mixed-methods examination of policy effects on attitudes and behavioral inclinations. *Biol. Conserv.* 189, 59–71. doi: 10.1016/j.biocon.2014.12.016

Bruskotter, J. T., and Fulton, D. C. (2012). Will hunters steward wolves? A comment on treves and martin. *Soc. Natural Resour.* 25 (1), 97–102. doi: 10.1080/08941920.2011.622735

Bruskotter, J. T., Singh, A., Fulton, D. C., and Slagle, K. (2015). Assessing tolerance for wildlife: Clarifying relations between concepts and measures. *Hum. Dimensions Wildlife* 20 (3), 255–270. doi: 10.1080/10871209.2015.1016387

Bruskotter, J. T., and Wilson, R. S. (2014). Determining where the wild things will be: Using psychological theory to find tolerance for large carnivores. *Conserv. Lett.* 7 (3), 158–165. doi: 10.1111/conl.12072

Carter, N. H., Riley, S. J., and Liu, J. (2012). Utility of a psychological framework for carnivore conservation. *Oryx* 46 (4), 525–535. doi: 10.1017/S0030605312000245

Carter, N. H., Riley, S. J., Shortridge, A., Shrestha, B. K., and Liu, J. (2014). Spatial assessment of attitudes toward tigers in Nepal. *Ambio* 43 (2), 125–137. doi: 10.1007/s13280-013-0421-7

Carter, N., Williamson, M. A., Gilbert, S., Lischka, S. A., Prugh, L. R., Lawler, J. J., et al. (2020). Integrated spatial analysis for human–wildlife coexistence in the American West. *Environ. Res. Lett.* 15 (2), 1–7. doi: 10.1088/1748-9326/ab60e1

Chang'a, A., de Souza, N., Muya, J., Keyyu, J., Mwakatobe, A., Malugu, L., et al. (2016). Scaling-up the use of chili fences for reducing human-elephant conflict across landscapes in Tanzania. *Trop. Conserv. Sci.* 9 (2), 921–930. doi: 10.1177/194008291600900220

Chen, Y., Marino, J., Chen, Y., Tao, Q., Sullivan, C. D., Shi, K., et al. (2016). Predicting hotspots of human-elephant conflict to inform mitigation strategies in xishuangbanna, Southwest China. *PloS One* 11 (9), e0162035. doi: 10.1371/journal.pone.0162035

Dar, N. I., Minhas, R. A., Zaman, Q., and Linkie, M. (2009). Predicting the patterns, perceptions and causes of human–carnivore conflict in and around machiara national park, Pakistan. *Biol. Conserv.* 142 (10), 2076–2082. doi: 10.1016/j.biocon.2009.04.003

Datta, R. (2015). A relational theoretical framework and meanings of land, nature, and sustainability for research with indigenous communities. *Local Environ.* 20 (1), 102–113. doi: 10.1080/13549839.2013.818957

De Angelo, C., Paviolo, A., Wiegand, T., Kanagaraj, R., and Di Bitetti, M. S. (2013). Understanding species persistence for defining conservation actions: A management landscape for jaguars in the Atlantic forest. *Biol. Conserv.* 159, 422–433. doi: 10.1016/j.biocon.2012.12.021

de Barros Ferraz, K. M. P. M., Marchini, S., Bogoni, J. A., Montanheiro Paolino, R., Landis, M., Fusco-Costa, R., et al. (2022). Best of both worlds: Combining ecological and social research to inform conservation decisions in a Neotropical biodiversity hotspot. *J. Nat. Conserv.* 66, 126–146. doi: 10.1016/j.jnc.2022.126146

Dickman, A. J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Anim. Conserv.* 13 (5), 458–466. doi: 10.1111/j.1469-1795.2010.00368.x

Dressler, W., Büscher, B., Schoon, M., Brockington, D. A. N., Hayes, T., Kull, C. A., et al. (2010). From hope to crisis and back again? A critical history of the global CBNRM narrative. *Environ. Conserv.* 37 (1), 5–15. doi: 10.1017/S0376892910000044

Earle, T. C. (2010). Trust in risk management: A model-based review of empirical research. *Risk Anal.* 30, 541–574. doi: 10.1111/j.1539-6924.2010.01398.x

Earle, T. C., and Siegrist, M. (2008). On the relation between trust and fairness in environmental risk management. *Risk Anal.* 28 (5), 1395–1414. doi: 10.1111/j.1539-6924.2008.01091.x

Flynn, J., Slovic, P., and Mertz, C. K. (1994). Gender, race, and perception of environmental health risks. *Risk Anal.* 14 (6), 1101–1108. doi: 10.1111/j.1539-6924.1994.tb00082.x

B. Frank, J. A. Glikman and S. Marchini (Eds.) (2019). *Human–wildlife interactions: Turning conflict into coexistence* Vol. Vol. 23 (Cambridge: Cambridge University Press).

Gebresenbet, F., Baraki, B., Yirga, G., Sillero-Zubiri, C., and Bauer, H. (2018). A culture of tolerance: Coexisting with large carnivores in the kafa highlands, Ethiopia. *Oryx* 52 (4), 751–760. doi: 10.1017/S0030605316001356

Gore, M. L., and Kahler, J. S. (2012). Gendered risk perceptions associated with human-wildlife conflict: implications for participatory conservation. *PloS One* 7 (3), e32901. doi: 10.1371/journal.pone.0032901

Gore, M. L., Wilson, R. S., Siemer, W. F., Wieczorek Hudenko, H., Clarke, C. E., Sol Hart, P., et al. (2009). Application of risk concepts to wildlife management: Special issue introduction. *Hum. Dimensions Wildlife* 14 (5), 301–313. doi: 10.1080/10871200903160944

Hill, C. M. (2021). Conflict is integral to human-wildlife coexistence. *Front. Conserv. Sci.* 2. doi: 10.3389/fcosc

Inskip, C., Ridout, M., Fahad, Z., Tully, R., Barlow, A., Barlow, C. G., et al. (2013). Human–tiger conflict in context: risks to lives and livelihoods in the Bangladesh sundarbans. *Hum. Ecol.* 41 (2), 169–186. doi: 10.1007/s10745-012-9556-6

Jepson, P., and Canney, S. (2003). Values-led conservation. *Global Ecol. Biogeography* 12 (4), 271–274. doi: 10.1046/j.1466-822X.2003.00019.x

Johansson, M., Sandström, C., Pedersen, E., and Ericsson, G. (2016). Factors governing human fear of wolves: moderating effects of geographical location and standpoint on protected nature. *Eur. J. Wildlife Res.* 62 (6), 749–760. doi: 10.1007/s10344-016-1054-5

Kansky, R., Kidd, M., and Knight, A. T. (2014). Meta-analysis of attitudes toward damage-causing mammalian wildlife. *Conserv. Biol.* 28 (4), 924–938. doi: 10.1111/cobi.12275

Kansky, R., Kidd, M., and Knight, A. T. (2016). A wildlife tolerance model and case study for understanding human wildlife conflicts. *Biol. Conserv.* 201, 137–145. doi: 10.1016/j.biocon.2016.07.002

Kansky, R., and Knight, A. T. (2014). Key factors driving attitudes towards large mammals in conflict with humans. *Biol. Conserv.* 179, 93–105. doi: 10.1016/j.biocon.2014.09.008

Karanth, K. K., Nichols, J. D., Karanth, K. U., Hines, J. E., and Christensen, N. L.Jr. (2010). The shrinking ark: patterns of large mammal extinctions in India. *Proc. R. Soc. B: Biol. Sci.* 277 (1690), 1971–1979. doi: 10.1098/rspb.2010.0171

Karlsson, J., and Sjöström, M. (2011). Subsidized fencing of livestock as a means of increasing tolerance for wolves. *Ecol. Soc.* 16 (1), 16–26. doi: 10.5751/ES-03878-160116

Laurila-Pant, M., Lehikoinen, A., Uusitalo, L., and Venesjärvi, R. (2015). How to value biodiversity in environmental management? *Ecol. Indic.* 55, 1–11. doi: 10.1016/j.ecolind.2015.02.034

Lecuyer, L., Calmé, S., Blanchet, F. G., Schmook, B., and White, R. M. (2019). Factors affecting feelings of justice in biodiversity conflicts: Toward fairer jaguar management in calakmul, Mexico. *Biol. Conserv.* 237, 133–144. doi: 10.1016/j.biocon.2019.06.017

Lecuyer, L., White, R. M., Schmook, B., and Calmé, S. (2018a). Building on common ground to address biodiversity conflicts and foster collaboration in environmental management. *J. Environ. Manage.* 220, 217–226. doi: 10.1016/j.jenvman.2018.05.014

Lecuyer, L., White, R. M., Schmook, B., Lemay, V., and Calmé, S. (2018b). The construction of feelings of justice in environmental management: An empirical study of multiple biodiversity conflicts in calakmul, Mexico. *J. Environ. Manage.* 213, 363–373. doi: 10.1016/j.jenvman.2018.02.050

Lischka, S. A., Teel, T. L., Johnson, H. E., Reed, S. E., Breck, S., Carlos, A. D., et al. (2018). A conceptual model for the integration of social and ecological information to understand human-wildlife interactions. *Biol. Conserv.* 225, 80–87. doi: 10.1016/j.biocon.2018.06.020

Liu, F., McShea, W. J., Garshelis, D. L., Zhu, X., Wang, D., and Shao, L. (2011). Human-wildlife conflicts influence attitudes but not necessarily behaviors: Factors driving the poaching of bears in China. *Biol. Conserv.* 144 (1), 538–547. doi: 10.1016/j.biocon.2010.10.009

Madden, F., and McQuinn, B. (2014). Conservation's blind spot: The case for conflict transformation in wildlife conservation. *Biol. Conserv.* 178, 97–106. doi: 10.1016/j.biocon.2014.07.015

Marchini, S., Ferraz, K.M.P.M.B., Foster, V., Reginato, T., Kotz, A., Barros, Y., et al. (2021). Planning for human-wildlife coexistence: Conceptual framework, workshop process, and a model for transdisciplinary collaboration. *Front. Conserv. Sci.* 2. doi: 10.3389/fcosc.2021.752953

Margulies, J. D., and Karanth, K. K. (2018). The production of human-wildlife conflict: A political animal geography of encounter. *Geoforum* 95, 153–164. doi: 10.1016/j.geoforum.2018.06.011

Marshall, K., White, R., and Fischer, A. (2007). Conflicts between humans over wildlife management: On the diversity of stakeholder attitudes and implications for conflict management. *Biodiversity Conserv.* 16 (11), 3129–3146. doi: 10.1007/s10531-007-9167-5

Mascia, M. B., Brosius, J. P., Dobson, T. A., Forbes, B. C., Horowitz, L., McKean, M. A., et al. (2003). Conservation and the social sciences. *Conserv. Biol.* 17 (3), 649–650. doi: 10.1046/j.1523-1739.2003.01738.x

Mech, L. D. (2017). Where can wolves live and how can we live with them? *Biol. Conserv.* 210 part A, 310–317. doi: 10.1016/j.biocon.2017.04.029

Miller, J. R. (2015). Mapping attack hotspots to mitigate human–carnivore conflict: Approaches and applications of spatial predation risk modeling. *Biodiversity Conserv.* 24 (12), 2887–2911. doi: 10.1007/s10531-015-0993-6

Muter, B. A., Gore, M. L., and Riley, S. J. (2013). Social contagion of risk perceptions in environmental management networks. *Risk Anal.* 33 (8), 1489–1499. doi: 10.1111/j.1539-6924.2012.01936.x

O'Brien, L., Marzano, M., and White, R. M. (2013). 'Participatory interdisciplinarity': Towards the integration of disciplinary diversity with stakeholder engagement for new models of knowledge production. *Sci. Public Policy* 40 (1), 51–61. doi: 10.1093/scipol/scs120

O'Connor, R. E., Bard, R. J., and Fisher, A. (1999). Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk Anal.* 19 (3), 461–471. doi: 10.1023/A:1007004813446

Olsoy, P. J., Zeller, K. A., Hicke, J. A., Quigley, H. B., Rabinowitz, A. R., and Thornton, D. H. (2016). Quantifying the effects of deforestation and fragmentation on a range-wide conservation plan for jaguars. *Biol. Conserv.* 203, 8–16. doi: 10.1016/j.biocon.2016.08.037

Peterson, M. N., Birckhead, J. L., Leong, K., Peterson, M. J., and Peterson, T. R. (2010). Rearticulating the myth of human-wildlife conflict. *Conserv. Lett.* 3 (2), 74–82. doi: 10.1111/j.1755-263X.2010.00099.x

Piédallu, B., Quenette, P. Y., Mounet, C., Lescureux, N., Borelli-Massines, M., Dubarry, E., et al. (2016). Spatial variation in public attitudes towards brown bears in the French pyrenees. *Biol. Conserv.* 197, 90–97. doi: 10.1016/j.biocon.2016.02.027

Rawluk, A., Ford, R., Anderson, N., and Williams, K. (2019). Exploring multiple dimensions of values and valuing: a conceptual framework for mapping and translating values for social-ecological research and practice. *Sustainability Sci.* 14 (5), 1187–1200. doi: 10.1007/s11625-018-0639-1

Redpath, S. M., Gutiérrez, R. J., Wood, K. A., and Young, J. (2015). *Conflicts in conservation: Navigating towards solutions.* (Cambridge, United Kingdom: United Kingdom by TJ Internacional Ltd. Padstow Cornwall). doi: 10.1017/9781139084574

Renn, O. (1992). "Concepts of risk: a classification," in *Social theories of risk*. Ed. S. Krimsky (Westport, Conn: Praeger), 53–79. doi: 10.18419/opus-7248

Riley, S. J., and Decker, D. J. (2000). Risk perception as a factor in wildlife stakeholder acceptance capacity for cougars in Montana. *Hum. Dimensions Wildlife* 5 (3), 50–62. doi: 10.1080/10871200009359187

Rodríguez, I., and Inturias, M. L. (2018). Conflict transformation in indigenous peoples' territories: Doing environmental justice with a 'decolonial turn'. *Dev. Stud. Res.* 5 (1), 90–105. doi: 10.1080/21665095.2018.1486220

Sjöberg, L. (1998). Worry and risk perception. *Risk Anal.* 18 (1), 85–93. doi: 10.1111/j.1539-6924.1998.tb00918.x

Sjölander-Lindqvist, A., Johansson, M., and Sandström, C. (2015). Individual and collective responses to large carnivore management: The roles of trust, representation, knowledge spheres, communication and leadership. *Wildlife Biol.* 21 (3), 175–185. doi: 10.2981/wlb.00065

Slagle, K. M., Bruskotter, J. T., and Wilson, R. S. (2012). The role of affect in public support and opposition to wolf management. *Hum. Dimensions Wildlife* 17 (1), 44–57. doi: 10.1080/10871209.2012.633237

Slimak, M. W., and Dietz, T. (2006). Personal values, beliefs, and ecological risk perception. *Risk Anal.* 26 (6), 1689–1705. doi: 10.1111/j.1539-6924.2006.00832.x

Slovic, P. (1987). Perception of risk. *Science* 236, 280–285. doi: 10.1017/CBO9781316422250.040

Smith, K., Barrett, C. B., and Box, P. W. (2000). Participatory risk mapping for targeting research and assistance: With an example from East African pastoralists. *World Dev.* 28 (11), 945–1959. doi: 10.1016/S0305-750X(00)00053-X

Soh, Y. H., Carrasco, L. R., Miquelle, D. G., Jiang, J., Yang, J., Stokes, E. J., et al. (2014). Spatial correlates of livestock depredation by amur tigers in hunchun, China: Relevance of prey density and implications for protected area management. *Biol. Conserv.* 169, 117–127. doi: 10.1016/j.biocon.2013.10.011

Sponarski, C. C., Miller, C. A., Vaske, J. J., and Spacapan, M. R. (2016). Modeling perceived risk from coyotes among Chicago residents. *Hum. Dimensions Wildlife* 21 (6), 491–505. doi: 10.1080/10871209.2016.1190989

Sponarski, C. C., Semeniuk, C., Glikman, J. A., Bath, A. J., and Musiani, M. (2013). Heterogeneity among rural resident attitudes toward wolves. *Hum. Dimensions Wildlife* 18 (4), 239–248. doi: 10.1080/10871209.2013.792022

Stern, M. J. (2008). Coercion, voluntary compliance and protest: the role of trust and legitimacy in combating local opposition to protected areas. *Environ. Conserv.* 35 (3), 200–210. doi: 10.1017/S037689290800502X

Stern, M. J., and Coleman, K. J. (2015). The multidimensionality of trust: Applications in collaborative natural resource management. *Soc. Natural Resour.* 28 (2), 117–132. doi: 10.1080/08941920.2014.945062

Struebig, M. J., Linkie, M., Deere, N. J., Martyr, D. J., Millyanawati, B., Faulkner, S. C., et al. (2018). Addressing human-tiger conflict using socio-ecological information on tolerance and risk. *Nat. Commun.* 9 (1), 3455. doi: 10.1038/s41467-018-05983-y

Thorn, M., Green, M., Dalerum, F., Bateman, P. W., and Scott, D. M. (2012). What drives human–carnivore conflict in the north West province of south Africa? *Biol. Conserv.* 150 (1), 23–32. doi: 10.1016/j.biocon.2012.02.017

Treves, A. (2009). "The human dimensions of conflicts with wildlife around protected areas" in *Wildlife and society: The science of human dimensions* (Washington D.C: Island Press), 214–228.

Treves, A., and Bruskotter, J. (2014). Tolerance for predatory wildlife. *Science* 344 (6183), 476–477. doi: 10.1126/science.1252690

Treves, A., and Martin, K. A. (2011). Hunters as stewards of wolves in Wisconsin and the northern rocky mountains, USA. *Soc. Natural Resour.* 24 (9), 984–994. doi: 10.1080/08941920.2011.559654

United Nations (UN) (2015) *Transforming our world: the 2030 agenda for sustainable development. A/RES/70/1. seventieth session. united nations general assembly*. Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld.

Vucetich, J. A., Burnham, D., Macdonald, E. A., Bruskotter, J. T., Marchini, S., Zimmermann, A., et al. (2018). Just conservation: What is it and should we pursue it? *Biol. Conserv.* 221, 23–33. doi: 10.1016/j.biocon.2018.02.022

White, R. M., Fischer, A., Marshall, K., Travis, J. M., Webb, T. J., Di Falco, S., et al. (2009). Developing an integrated conceptual framework to understand biodiversity conflicts. *Land Use Policy* 26 (2), 242–253. doi: 10.1016/j.landusepol.2008.03.005

Williamson, M. A., Schwartz, M. W., and Lubell, M. N. (2018). Spatially explicit analytical models for social–ecological systems. *Bioscience* 68 (11), 885–895. doi: 10.1093/biosci/biy094

Wilson, S., Davies, T. E., Hazarika, N., and Zimmermann, A. (2015). Understanding spatial and temporal patterns of human–elephant conflict in Assam, India. *Oryx* 49 (1), 140–149. doi: 10.1017/S0030605313000513

Wilson, S. M., Madel, M. J., Mattson, D. J., Graham, J. M., Burchfield, J. A., and Belsky, J. M. (2005). Natural landscape features, human-related attractants, and conflict hotspots: a spatial analysis of human–grizzly bear conflicts. *Ursus* 16 (1), 117–129. doi: 10.2192/1537-6176(2005)016[0117:NLFHAA]2.0.CO;2

Woodroffe, R., and Ginsberg, J. R. (1998). Edge effects and the extinction of populations inside protected areas. *Science* 280 (5372), 2126–2128. doi: 10.1126/science.280.5372.2126

Young, J. C., Marzano, M., White, R. M., McCracken, D. I., Redpath, S. M., Carss, D. N., et al. (2010). The emergence of biodiversity conflicts from biodiversity impacts: characteristics and management strategies. *Biodiversity Conserv.* 19 (14), 3973–3990. doi: 10.1007/s10531-010-9941-7

Young, J. C., Searle, K., Butler, A., Simmons, P., Watt, A. D., and Jordan, A. (2016). The role of trust in the resolution of conservation conflicts. *Biol. Conserv.* 195, 196–202. doi: 10.1016/j.biocon.2015.12.030

Zanin, M., Sollmann, R., Tôrres, N. M., Furtado, M. M., Jácomo, A. T., Silveira, L., et al. (2015). Landscapes attributes and their consequences on jaguar panthera onca and cattle depredation occurrence. *Eur. J. Wildlife Res.* 61 (4), 529–537. doi: 10.1007/s10344-015-0924-6

Zimmermann, A., Johnson, P., de Barros, A. E., Inskip, C., Amit, R., Soto, E. C., et al. (2021). Every case is different: Cautionary insights about generalisations in human-wildlife conflict from a range-wide study of people and jaguars. *Biol. Conserv.* 260, 109185. doi: 10.1016/j.biocon.2021.109185

Zimmermann, A., McQuinn, B., and Macdonald, D. W. (2020). Levels of conflict over wildlife: Understanding and addressing the right problem. *Conserv. Sci. Pract.* 2 (10), e259. doi: 10.1111/csp2.259