

The socioecology of fear: A critical geographical consideration of human-wolf-livestock conflict

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Key messages

- Human-wolf-livestock coexistence efforts in Washington rely on sustaining wolves' fear of people, often described as “innate” even as it is reproduced through human-wolf interactions.
- Mitigating wolf-livestock conflict requires managing human social norms, values, and assumptions about wolf behaviour that are interwoven with ecological fear dynamics.
- Interdisciplinary dialogue between the social and biophysical sciences, inspired by critical physical geography, can enhance the study of socioecological processes, including human-wildlife conflict dynamics.

Animal fear can be an important driver of ecological community structure: predators affect prey not only through predation, but also by inducing changes in behaviour and distribution—a phenomenon evocatively called the “ecology of fear.” The return of wolves to the western United States is a notable instance of such dynamics, yet plays out in a complex socioecological system where efforts to mitigate impacts on livestock rely on manipulating wolves' fear of people. Examining Washington state's efforts to affect wolf behaviour to reduce livestock predation, we argue that this approach to coexistence with wolves is predicated on relations of fear: people, livestock, and wolves can arguably share landscapes with minimal conflict, as long as wolves are adequately afraid. We introduce the “socioecology of fear” as an interdisciplinary framework for examining the interwoven social and ecological processes of human-wildlife conflict management. Beyond frequently voiced ideas about wolves' “innate” fear, we examine how fear is (re)produced through human-wolf interactions and deeply shaped by human social processes. We contribute to the critical physical geography project by integrating critical social analysis with ecological theory, conducted through collaborative interdisciplinary dialogue. Such integrative practice is essential for understanding the complex challenges of managing wildlife in the Anthropocene.

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La socioécologie de la peur : une analyse de géographie critique du conflit homme-loup-bétail

La peur chez les animaux peut être un facteur important de la structure des communautés écologiques. En effet, les prédateurs affectent les proies non seulement par la prédation mais aussi en induisant des changements de comportement et de répartition. Ce phénomène est appelé de manière évocatrice « l'écologie de la peur ». Le retour des loups dans l'ouest des États-Unis est un exemple notable de cette dynamique qui s'inscrit selon nous dans un système socioécologique complexe incluant la manipulation volontaire de la peur chez les loups. En étudiant les efforts déployés par l'État de Washington pour modifier le comportement des loups afin de protéger le bétail, nous soutenons que la coexistence avec les loups repose sur une approche basée sur la peur: les êtres humains, le bétail et les loups peuvent partager les territoires, à condition que les loups aient suffisamment peur. Sur la plan théorique, nous présentons la « socioécologie de la peur » comme un cadre interdisciplinaire permettant d'examiner les processus sociaux et écologiques entremêlés dans la gestion des conflits entre les humains et la faune sauvage. Par ailleurs, nous analysons la manière dont la peur des loups est (re)produite par les interactions humains-loup et comment celle-ci est profondément façonnée par les processus sociaux. Au final, nous contribuons au projet de géographie physique critique en intégrant l'analyse sociale critique à la théorie écologique, par le biais d'un dialogue interdisciplinaire collaboratif.

Mots clés : conflit humains-faune, dynamique de la peur inter-espèces, interdisciplinarité, géographie physique critique, loups

Introduction

Conflict over wolves (*Canis lupus*) is a preeminent example of human-wildlife conflict (HWC) and a major challenge for conservation around the world (Musiani et al. 2009; Treves and Bruskotter 2011). Even as the return of wolves to landscapes where they were previously eradicated is celebrated as a conservation success, opposition to wolves remains—especially on multiple-use landscapes where predation of livestock poses challenges for producers and resource managers alike (Muhly and Musiani 2009). Efforts to reduce wolf-livestock conflicts, and thereby ease the social tensions that accompany them, are widespread across the growing range of the species in North America (Mech 2017; Martin 2021b). However, while many agree on the goal of promoting “coexistence” between people and wolves, there is little agreement about exactly what this means (Peterson et al. 2010; Lute et al. 2020; Martin et al. 2021; Pooley et al. 2021), and conflict mitigation approaches can vary widely across jurisdictions. This paper focuses on one such ongoing effort in the state of Washington in the United States (US) to demonstrate how wildlife policy and practices reflect complex and co-produced social and ecological relations.

Washington's approach, described as an attempt to “influence/change wolf pack behavior to reduce the

potential for recurrent wolf depredations on livestock” (WDFW Washington Department of Fish and Wildlife, 2017, 2), places a significant emphasis on the manipulation of fear dynamics, using various tools and techniques to cultivate wolves' fear of people. Fear dynamics between predators and prey are well known to be an important driving mechanism of the structure of ecological communities and are the subject of an extensive literature in the ecological sciences. Yet human-wolf relationships are also strongly characterized by fear. Moreover, even as wolves' fear of people is commonly described as “innate,” it is simultaneously inculcated and manipulated by livestock producers and wildlife managers deploying tools to influence or change wolf behaviour. What is often described as coexistence is thus predicated on sustaining relations of fear: people and livestock can (arguably) share landscapes with wolves with minimal conflict, *as long as wolves are adequately afraid*.

In this paper, we extend the concept of the “ecology of fear” from the natural sciences to critically examine and interpret social science data regarding human-wolf interactions drawn from an ethnographic case study of wolf management in Washington state. Although the study of wild animal behaviour conventionally falls to the natural sciences, there is increasing recognition

that human-wildlife coexistence is simultaneously a social and ecological issue (Baruch-Mordo et al. 2009; Dickman 2010; Margulies and Karanth 2018; Manfredo et al. 2019), and that wolf behaviour is directly affected by human processes and politics. This recognition has resulted in calls for more attention to the human dimensions of conservation conflicts and growing transdisciplinary dialogue between the social and natural sciences (Woodroffe et al. 2005; Drury et al. 2011; Bennett et al. 2017; Charnley et al. 2017; Frank et al. 2019; Harrison and Loring 2020; Martin 2021b).

We see human-wolf-livestock conflict as a prime opportunity for integrative critical science and cross-disciplinary dialogue, raising ecological questions about animal behaviour alongside social and political questions of how people demarcate space for particular uses and intervene to influence ecological processes and outcomes. We draw together existing frameworks in wildlife ecology that understand animal behaviour as linked to human activities, and work in human geography and political ecology on the complex social dynamics of those activities. Accordingly, we understand wildlife management as a *socionatural process*, requiring a transdisciplinary approach spanning the social and biophysical sciences. We thus align our work with the project of critical physical geography (CPG), which draws on the integrative strengths of geography to bring social and biophysical theories, methods, and data together to “investigate material landscapes, social dynamics, and knowledge politics together, as they co-constitute each other” (Lave et al. 2014, 3), in the context of the fundamentally socionatural world signified by the Anthropocene (Biermann et al. 2020). Through critical dialogue and collaboration between natural and social scientists, we explore this controversial case of human-wildlife conflict and coexistence with an applied orientation to contemporary, on-the-ground management challenges.

In what follows, we offer a critical investigation of the material landscapes, social dynamics, and politics of knowledge at play in efforts to “change wolf behaviour” in Washington. We begin with an integrative review drawing together disparate disciplinary literatures addressing fear dynamics in human-wolf-livestock systems. Next, we describe the collaborative analytical process through which we brought these literatures to bear on our case

study, which we offer as an effort at developing more critical wildlife science. We then turn to our empirical research examining Washington's wolf management, emphasizing discussions about how, why, and where wolves are (or should be) afraid. Our analysis shows how efforts to mitigate conflict involve managing complex socionatural fear dynamics with the intent to produce desired risk-avoidance adaptations in animal behaviour. The social (re)production of discourses of animal fear serves to normalize relations of chronic fear between people and wolves, with cascading effects on human management interventions, wolf behaviour, and the potential for human-wolf coexistence. Drawing on this analysis of interwoven social and ecological dynamics, we conclude by developing the concept of the “socioecology of fear,” a framework for understanding the complex social and ecological dynamics of human-wildlife fear relations relevant to our case study and other instances of wildlife management.

Fear dynamics in human-wolf-livestock socioecological systems

Fear is a major theme in stories about wolves and their re-establishment in the American West. The return of wolves to Yellowstone National Park, for instance, is described as the driving force in an oft-celebrated process of “rewilding,” via cascading trophic effects triggered by the fright wolves give to the region's ungulate populations (Ripple and Beschta 2004; Klein 2018). This narrative emphasizes the behaviourally-mediated effects of predators, evocatively described by ecologists as the “ecology of fear” (Brown et al. 1999; Gaynor et al. 2021). Even as recent evidence suggests that the role of fear in the ecology of Yellowstone is more limited and complicated than early studies indicated (Mech 2012; Middleton et al. 2013; Kohl et al. 2018), this process remains a powerful illustration of the importance of fear dynamics in shaping the structure of ecological communities.

Meanwhile, the human-wolf relationship has also long been characterized by fear, as wolves are “downgraded from ultimate to penultimate predator by humans” (Oriol-Cotterill et al. 2015, 1263). Over centuries of persecution, wolves have learned to recognize people as a threat and avoid them (Mech and Boitani 2010). Fear of humans is thus an

evolutionary adaptation, even as wolves' high behavioural plasticity creates potential for habituation, a particular concern in contexts where wolves may be tempted by the presence of livestock as a food source. The fear is often mutual: the extermination campaign conducted by settlers across the US in the 19th and early 20th centuries was significantly motivated by human fear—both mortal fear of a (perceived) savage, rapacious beast, and pragmatic fear of the impacts of livestock losses amid the landscape's conversion to colonial capitalist agricultural production (Coleman 2006). Even as wolves' return from the brink of eradication is often ascribed to a cultural re-evaluation of the species (Kellert et al. 1996; Nie 2003; Wise 2016), significant human fear of wolves remains.

Fear is thus a boundary concept across the social and ecological sciences, but with different connotations for scientists, wildlife managers, and stakeholders. Social science scholarship on HWC recognizes fear as an important psycho-social dynamic influencing perceptions, values, attitudes, and behaviours toward wildlife (Houston et al. 2010; Johansson et al. 2012). Negative emotions like fear interact with socioecological dynamics across social and spatial scales, and influence individual and collective actions and identities related to resource governance (Sultana 2011; González-Hidalgo and Zografos 2020; Egge and Ajibade 2021; Epstein et al. 2021). In the ecological literature, meanwhile, fear is often synonymous with “risk perception,” referring to animals' capacity to perceive stimuli associated with threats such as predators, shaping risk avoidance behaviours (Lima and Dill 1990; Gaynor et al. 2021). In this sense, fear dynamics are observed even in animals that may not experience emotion per se, referring to instinctive responses of vigilance and anti-predator behaviour.

As wolves have returned to shared working landscapes across the American West—including expanding their range well beyond the protected areas where ecological fear effects have largely been described—they enter new sociopolitical contexts dominated by human land uses, governance structures, and social processes. Here, human impacts on ecosystems can outweigh “natural” predator effects (Ciuti et al. 2012), raising questions about the transferability of ecological findings about interspecies fear dynamics as observed in protected areas. Although strongly supported by

conservation NGOs and species restoration advocates, wolf return remains a source of contention, as wolves present material and symbolic challenges to resource users and rural residents. Wolves transgress the boundaries of spaces assumed by some human communities to be “safe” from predator presence (Philo and Wilbert 2000; Buller 2008; Collard 2012), which in turn reduces tolerance and support for conservation (Treves and Karanth 2003; Miller et al. 2016).

Political debate over wolf conservation and belonging is overlaid on a backdrop of human fear, including emotional responses (e.g., fear of wolf attacks), as well as broader anxieties around the American West's ongoing economic, social, and ecological transformations (Nelson 2001; Robbins et al. 2009). Where wolf recolonization overlaps with shifting local economies and demographics—particularly a declining emphasis on the “traditional” extractive economic basis of the region—the return of wolves has generated social conflict, with wolves frequently interpreted as symbolic of a loss of local control over or access to landscapes and resources, or the extension of governmental power (Walker and Fortmann 2003; Gosnell and Travis 2005; Martin 2020). Wolves thus can exacerbate pre-existing conflicts over land use and regional futures, with “rewilding” conceived as a threat to “heritage landscapes” and “place identity” (Drenthen 2018; cf. Foreman 2004; Buller 2008; Wuerthner 2019). Critical scholarship on human-wildlife conflict, drawing on insights from political ecology and more-than-human geography, complicates notions of resolving this conflict simply by building human “tolerance,” drawing attention to the complex historical, political-economic, and social context around wolf return (Nie 2003; Robbins et al. 2014; Margulies and Karanth 2018; De Silva and Srinivasan 2019).

The much-touted concept of “coexistence” offers an optimistic vision of people, livestock, and wolves sharing the same landscape while minimizing impacts on one another (Carter and Linnell 2016; Lute and Carter 2020; Martin et al. 2021). Since reintroduction, and particularly in the wake of the 2011 species delisting across the US Northern Rocky Mountain region, efforts to reduce conflict often rely on targeted killing (“lethal removal”) of “problem wolves” that attack livestock (Bangs et al. 2006). The effectiveness of lethal predator control to reduce conflict, however, is

contested (DeCesare et al. 2018; Miller et al. 2016; van Eeden et al. 2018; Treves et al. 2019), with public disapproval of lethal wildlife control (Bruskotter et al. 2007; Slagle et al. 2017)—especially in states like Washington with strong environmentalist constituencies (van Eeden et al. 2020)—contributing to increasing emphasis on non-lethal solutions (Treves and Karanth 2003; Stone et al. 2017; Frank et al. 2019; Martin 2021b).

Many widely promoted non-lethal deterrents (see Smith et al. 2014; Stone et al. 2016) aim to support coexistence by deterring livestock predation via the manipulation of wolves' fear (Rinfret 2009; Hodgetts and Lorimer 2020). These employ sensory cues that wolves associate with risk—either due to the novelty of the cue or its association with predation risk over evolutionary history—to prevent livestock predation (Miller and Schmitz 2019; Gaynor et al. 2021). For instance, human presence and livestock guardian dogs are used based on the expectation that wolves fear and avoid them; herders or range riders haze wolves away using lights, noisemakers, and non-lethal munitions; automated (radio- or motion-activated) lights or sirens “stretch” the effects of hazing when people are absent; and wolf-deterrent flagging (fladry) relies on wolf neophobia (and can be electrified for additional deterrent effect) (Miller et al. 2016; Wilkinson et al. 2020). Finally, lethal removal, while more typically considered as a tool for reducing conflict via population reduction, is also sometimes discussed in terms of inducing fear: “surviving predators [may] be deterred from threatening human interests by sensing the loss of conspecifics was caused by humans” (Treves et al. 2019, 3). However, genetic variability plays a significant role in wolf behaviour toward livestock and may limit the role of learning that is often assumed to apply to deterrence techniques (Fabbri et al. 2018). In theory, removal could also work (whether intentionally or not) via a mechanism of artificial selection to promote more cautious or fearful wolf behaviour.

Research is ongoing around the effectiveness of these various tools and techniques for reducing livestock predation (Miller et al. 2016; Eklund et al. 2017; Stone et al. 2017; van Eeden et al. 2018; Wilkinson et al. 2020; Volski et al. 2021). Many fear-based deterrence tools and management interventions rely on disruptive stimuli and aversive conditioning—scaring wolves off in the moment

of attack, or associating negative stimuli (e.g., the electric shock of “turbo fladry”) with attacking livestock in order to change behaviour patterns (Shivik et al. 2003; Smith et al. 2014; Snijders et al. 2019). These are often inherently spatial, creating a “landscape of fear” in which wolves perceive risk in specific places and, hopefully, avoid them (Laundre et al. 2010; Gaynor et al. 2019; Miller and Schmitz 2019). Although the “ecology of fear” framework has thus been conceptually extended to include the effects of active human management of wildlife—described as the “applied ecology of fear” (Gaynor et al. 2021)—further research is needed to understand the processes by which wolf fear is produced and sustained in practice.

We treat animal fear as a *socionatural* phenomenon, produced through imbricated processes that cannot be divided into “natural” and “social” categories. The critical human geography concept of “socionature” (Braun and Castree 1998; Whatmore 2002; Swyngedouw 2004) signifies integration across the often-divided realms of human (social) and nonhuman (natural/ecological) processes and phenomena. While “socioecological” is widely used in the environmental sciences to refer to linkages between these systems, they are still often conceptually discrete; in contrast, “socionature” signifies a non-binary framing in which the two are never ontologically distinct in the first place (Sundberg 2014; Mansfield and Doyle 2017; Nightingale 2019). Framing animal fear as the *socionatural* product of human-nonhuman interactions—and thus, a crucial aspect of the *socioecological* dynamics of human-wolf livestock conflict—aligns with the growing body of work in CPG that emphasizes the entangled production of biophysical phenomena and processes by and with human social dynamics.

Our collaborative research methodology for more “critical” human-wildlife science

This paper combines qualitative data collection activities and findings with a collaborative, multi-disciplinary analysis and collective reflection on social and ecological approaches to questions of HWC. Ethnographic fieldwork was conducted by the lead author, examining social controversy over

wolf management in Washington, including the ongoing debate over lethal and non-lethal techniques for reducing conflict. Fieldwork included participant observation (e.g., attendance at the state's Wolf Advisory Group meetings); informal conversations and formal semi-structured interviews with scientists, state and federal agency staff, conservationists, livestock producers, and local residents; and textual analysis of documents related to wolf conflict and controversy. Our focus on Washington's wolf management is situated within the context of wolf return and human-wolf-livestock conflict dynamics across the western US, where members of our team are engaged in multiple parallel social and ecological research projects examining human-wolf conflict and coexistence from a diverse range of (inter)disciplinary perspectives.

We approached data analysis and interpretation of this case study as a process of collaboration and critical engagement across disciplinary boundaries, which we offer as a methodological contribution to the growing field of CPG. This emerging subfield draws on geography's integrative strengths as a source of "intellectual vitality" for addressing the socioecological challenges of the Anthropocene (Lave et al. 2014; Lave et al. 2018). CPG draws on and remains in dialogue with cognate fields including political ecology, science and technology studies, and land use science (Lave et al. 2018; cf. Martin et al. 2019), bringing together natural and social science insights to consider eco-social transformation and co-production, and combining an attentiveness to power relations with a serious engagement with biophysical sciences and systems.

For our team, CPG represents not merely a more "critical" approach within the field of physical geography, or to the interpretation of biophysical data, but a broad call for research that "brings together natural and social science methods, concepts, and theories" (Biermann et al. 2021, 225) to develop integrative understandings of ecological and social systems and processes, with attention to human power dynamics, social constructions of nature, and the politics of knowledge production itself. In this way CPG is "not just a development for geography" but has aims that "apply equally in other disciplines, such as Environmental Sciences" (Lane 2019, 52), including specifically those sciences relevant to wildlife conservation and management. As Simon (2018) and Goldman

(2018) have both noted, resource management and wildlife conservation practices are inherently political, even as they are "de-politicized and obscured behind a series of scientific framings and policy debates," with particular places, processes, and patterns "'spun' as strangely natural and inviolable" (Simon 2018, 175).

Our work here builds from this existing body of research applying the insights of CPG to environmental science, as well as a broader scholarship of increasingly critical interventions around human-wildlife conflict and coexistence (e.g., Margulies and Karanth 2018; Büscher and Fletcher 2020). The "foundational premise [of the Anthropocene] that the biophysical world is now profoundly social" (Biermann et al. 2020, 1) challenges not only geographers but also ecologists, wildlife managers, and others to move beyond an emphasis on "natural" landscapes and processes and pay attention to what are commonly perceived to be inferior landscapes altered by anthropogenic forces (Urban 2018) and the social processes that produce them. A logical corollary is the study of similarly human-impacted animals, such as feral, hybrid, or invasive species, that Rutherford (2018) calls "animals of the Anthropocene." Yet as the example of wolf deterrence through fear aptly demonstrates, even emblematically "wild" species such as wolves are also the product of entangled socio-natural (and thus inherently political) processes deserving of critical interrogation.

According to Lave et al. (2018), what distinguishes CPG research is not a particular suite of methods for studying such socionatural processes, but rather the practice of "reaching across" disciplinary and methodological divides to interpret and understand them. Rather than simply analyze qualitative, ethnographic data within a theoretical framework drawn from the social sciences, as would be the norm in critical *human* geography, our lead author therefore invited an interdisciplinary team of collaborators to join in a series of synthesis-oriented, critical discussions of the case study. Our author team brought together essential theoretical contributions from our respective fields of the social sciences (human geography and political ecology) and natural sciences (wildlife and community ecology) to build the conceptual approach of this paper. We sought out generative cross-pollinations (cf. Blaikie and Brookfield 1987; Martin et al. 2019), tracing connections between

concepts and insights from social and ecological theory to interpret and explain our case study material. Our efforts to understand the role of wolves' fear of people, as a behavioural response that is simultaneously "natural" and anthropogenically produced, led us into conversations that promptly challenged the taken-for-granted assumptions of our various disciplinary backgrounds. This required a re-examination of our conceptual frameworks, bridging our disciplines' frequent "mutual ignorance" (Lave et al. 2018) and sparking innovative insights.

This process of ongoing, collaborative exchange between social and biophysical scientists goes beyond paying lip service to interdisciplinarity, making possible the integration here of theoretical work from human geography and wildlife ecology that has not previously been in conversation. Our practice of transdisciplinary integration required developing mutually intelligible vocabulary and seeking coherence across methods and concepts not traditionally combined (Drury et al. 2011; Martin 2021b). Building from geography's unique strength as an "anti-disciplinary" discipline (Lane 2019), we aim to develop a more critical, transdisciplinary approach to the study of human-wildlife dynamics that have often been situated and theorized in the provinces of wildlife ecology and the human dimensions of wildlife management. While further integration is still needed on the level of methodology (e.g., drawing together biophysical and social data), the integration of "concepts and theories" (Biermann et al. 2021) represented here paves the way for future research in critical, interdisciplinary geographies of wildlife. Moreover, this approach offers insights not only to wildlife managers around questions of human-wildlife coexistence, but to the development of research processes and methods for interdisciplinary work more broadly. The CPG literature provides a useful guiding set of principles for organizing an interdisciplinary collaboration between social and natural scientists and developing practices for more critical and integrative science. Taking CPG as the spark for critical practices of environmental science, broadly construed, we explore the analytical and practical opportunities made possible for studying human-wildlife conflict and coexistence—and environmental management in the Anthropocene more generally—through intentional interdisciplinary synthesis.

Discourses of fear in Washington's wolf management

Washington is a prime example of ongoing human-wolf-livestock conflict and provides a case study evocative of broader themes of such conflict elsewhere in the region and around the world. Social conflict over wolves in Washington has simmered since the first resident pack was confirmed in 2008. In northeastern Washington, where resurgent wolves' territories overlap significantly with both private ranch lands and multiple-use public lands where livestock are permitted to graze (such as the Colville National Forest), conflict has flared repeatedly after multiple controversial lethal removals by the Washington Department of Fish and Wildlife (WDFW). Washington's approach to wolf-livestock conflict mitigation is laid out in the state's "wolf-livestock interaction protocol," a document developed by Washington's Wolf Advisory Group (WAG), which guides WDFW in implementation of both lethal and non-lethal measures. WDFW has aimed to make lethal removal a tool of last resort, requiring livestock producers to use non-lethal approaches and requiring evidence of repeated livestock predation before WDFW will step in to remove wolves. This approach contrasts with current wolf policy in Idaho, Montana, and Wyoming, as well as on the lands of the Confederated Tribes of the Colville Reservation within Washington, which are managed by the tribes under a separate management plan (Colville Confederated Tribes Fish and Wildlife Department 2017). In jurisdictions where the wolf population is considered "recovered," targeted lethal removal of wolves is often among the first tools used to address conflict situations. Washington's protocol, and specifically the state's limitations on the use of lethal removal, has long been the subject of heated debate by the WAG (Anderson 2021), the state's Fish and Wildlife Commission, and the general public.

The wolf issue is entangled with political polarization in the context of a strong urban-rural divide in Washington. Wolf advocates who oppose lethal removal—supported by a politically progressive populace on the more urban western side of the state (van Eeden et al. 2020)—see Washington as an opportunity for a more protective wolf policy. Meanwhile, many rural residents, and especially livestock producers, argue for more aggressive use

of lethal removal and see state policies protecting wolves as government overreach. These social dynamics in Washington are a microcosm of the wolf issue nationally, entangled with broader questions of land use, urban/rural divisions, competing notions of identity and history, and questions of local control versus governmental authority.

We examine the social context of wolf conservation in Washington, specifically focusing on discussions about wolf fear of people in debates over lethal and non-lethal management tools. Wolves' fear of people is commonly understood to be a central dynamic of conflict mitigation, but different understandings of the wolf-human fear relationship proliferate, pointing to different ways of mitigating conflict. The pivotal debate over lethal versus non-lethal deterrence hinges on questions about wolf fear. We examine those debates to understand how "fear" is understood and deployed discursively and materially in the construction and normalization of particular human-wolf relations, with significant effects on both social and ecological dynamics and related ecological management practices.

One often repeated view is that wolves are and should be "naturally" or "innately" afraid of people. In the words of one WDFW wildlife manager, wolves are "in general very shy and scared of people. That's naturally normal for wolves to be afraid of people." Of course, many biologists are quick to note that wolves' fear of humans is the evolutionary result of thousands of years of threatening human-wolf interactions, and recent work examining the history of domestication demonstrates that this relationship is not inevitable (Mech 2019). Nonetheless, the premise of "naturally normal" fear prevails in public discourse. Maintaining wolves' "natural fear of humans and human activities," as described in Washington's Wolf Conservation and Management Plan (Wiles et al. 2011, 233), is widely understood to be key to not only protecting public safety but to protecting wolves themselves, since habituated wolves are likely to be killed. From this perspective, insufficient fear of people is what leads to problems with wolves. Paradoxically, wildlife management to "keep wolves wild" requires particular, intentional human interventions (e.g., hazing) to reinforce wolves' fear, understood as an "innate" or natural phenomenon even as it is (re)produced by

human activities. As one Washington conservationist said, "we always tell people, shoot an air horn, do something to keep it afraid. Don't have a neutral experience with a wolf."

The logic of normalizing negative or threatening interactions in order to sustain fear of people is echoed in wolf-livestock conflict deterrence. The state's efforts to "influence/change wolf pack behavior" (WDFW 2017, 2) also include modifications to livestock husbandry practices to reduce spatial overlap and attractiveness to wolves, but strong emphasis is placed on fear-based non-lethal deterrents, often implemented by WDFW "conflict specialists" working in cooperation with livestock producers. Tools such as fladry, range riders, and manual or automated scare devices to "haze" wolves are emphasized both in the protocol and in the practical guide to "living with livestock and wolves" commissioned by WDFW (Smith et al. 2014). Wildlife managers often frame non-lethal tools as key to maintaining sufficient fear in the wolf population to prevent livestock predation (in the words of one WDFW employee, "if you get a chance to haze wolves away from livestock, by God, do it") and also as a means of avoiding "getting to lethal."

Fear-based deterrents are thus understood by proponents as setting "healthy boundaries" for human-wolf relations, for the benefit of the wolves themselves as much as for the protection of livestock. As one livestock producer told the WAG, "When wolves have a healthy fear of humans and those boundaries are set, it does help those wolves on the landscape survive." In some cases, these boundaries are literal lines on the landscape, such as a line of fladry (supported by human patrol or automated deterrents) to delineate secure space for livestock that wolves fear to enter. This approach amounts to the creation of spatially explicit landscapes of fear where wolves perceive increased risk in particular locations. Often, though, the boundary is behavioural: wolves "cross the line" when they repeatedly prey on livestock (understood to be off-limits regardless of where they are on the landscape). This boundary is set in the protocol's guidelines for lethal removal, done only after a certain threshold of confirmed livestock predation by the same wolf/wolves: four occurrences in 10 months or three in 30 days.

The idea that non-lethal fear-based tools work—not only in the short term to disrupt attacks, but also as aversive conditioning to change behaviour

more permanently—is debated. Some wildlife managers are sceptical: one interviewee, experienced with deploying non-lethal tools, said that aversive conditioning of wolves isn't really possible—it's "just too hard [because] you would have to catch them every single time." On the other hand, a range rider explained his work on wolf deterrence to the WAG, saying "if this is done right you're conditioning those animals" (the wolves) to think "wow, every time I come in here there's a weird-looking guy on a horse ... they can be conditioned like that," he insisted.

One point of widespread agreement among many stakeholders is that non-lethal deterrents are much more effective when used *proactively* rather than attempting to "change" behaviour after livestock predation begins. While ranchers and wolf advocates often find little common ground on wolf management in Washington, they largely agree that it is easier to discourage wolves from switching prey in the first place, than it is to get them to switch back once they become accustomed to attacking livestock. "You're not gonna teach wolves to change their diet," one WAG member said; you might as well "teach them to speak English [or] teach them to eat tofu." For many, this argument supports proactive changes to husbandry practices and the use of non-lethal deterrents to keep wolves and livestock physically separated, based on the expectation that spatial overlap often leads to conflict. However, the argument that wolves cannot be re-taught once they recognize livestock as a food source is also used to call for more frequent, faster use of lethal removal: as one producer put it, there's "no way we're gonna non-lethal our way out" of the situation once livestock predation begins.

Significantly, lethal removal is often described as a tool for "changing behaviour" as well, although stakeholders hold different views about its purpose. As one local resident of rural northeastern Washington said, "the joke out here is, if you shoot it [dead], you've changed its behavior." Indeed, ecological research has found that eliminating the immediate threat of a specific "problem wolf" or pack can reduce livestock predation in the short term (as one wildlife biologist says, "that's what we know lethal can do"), though other wolves may quickly move into the same territory (Bradley et al. 2015). The state protocol goes a step further, explaining that the "strategy [of lethal removal] is

to attempt to change pack behavior by removing a minimum but sufficient number of wolves before that behaviour is reinforced by additional depredations on livestock" (WDFW 2017). State wildlife biologists describe this in terms of "disrupting pack dynamics," which may include eliminating the problem wolf within the pack before other individuals learn to target livestock, and/or reducing the overall food needs of a pack.

In contrast to these narrower goals, many livestock producers and even some WDFW staff describe lethal removal as a tactic for disciplining wolves via the threat of punishment. One WDFW staff member describes lethal removal via the analogy of behavioural conditioning: "It's just like training a dog," he explains, "if it takes two weeks [from livestock predation to lethal response], that dog's not gonna know what it's being punished for." Asked how a dead wolf can learn from its mistakes, he argues that "you're sending a message to the pack." Though wolf advocates question the premise that lethal removal has effects beyond the individual, saying "it's not like the wolf says, my brother or father got killed eating cows so I won't eat cows anymore," many livestock producers suggest sending the message more directly, by leaving a livestock carcass out and waiting nearby to kill a wolf when they return to it. As one livestock producer argued, "I think if you shoot one of those things, then the others see that. They're intelligent animals ... if they can find easier food sources, then they will do it." Elaborating on this idea, another producer argues that the production of wolves' fear is the basis for the success of other techniques of deterrence: "right now these wolves have no reason to be afraid of humans ... if you gave them a reason, maybe other wolves would be a lot more receptive to non-lethals." In this sense, they conclude, the "best non-lethal is a good lethal."

The complexities and confusions of managing wolves via fear

Washington's efforts to "influence/change wolf behaviour" rely heavily on the manipulation of fear dynamics, even if they have not been explicitly framed as such by managers. The intertwined mechanisms of actively disrupting attacks, protecting certain spaces for livestock on the

landscape via fear-based deterrents, using tools for aversive conditioning of wolves to prevent habituation and/or prey switching, and using lethal removal to eliminate wolves that do not learn to behave, collectively amount to managing wolf behaviour through manipulating fear responses. What is often described as “coexistence” with wolves should be understood as the application of ecological knowledge about fear dynamics to manipulate wolves’ behaviour to achieve desired ecological dynamics/outcomes, namely reducing livestock predation (Gaynor et al. 2021).

Washington’s effort to achieve coexistence in a way that minimizes lethal removal (in contrast to most Western states where removal is routine) has made deterrence via fear a central aspect of wolf management. This focus on non-lethal mitigation has even led to a reframing of how Washington’s resource managers and livestock producers think about lethal removal: considering it as a tool for producing fear as opposed to primarily a population control mechanism. Complicating the idea that coexistence with predators is achieved by reducing human-caused mortality risk (Oriol-Cotterill et al. 2015), coexistence here relies on increasing wolves’ *perception* of risk (potentially including increasing mortality risk via lethal removal), cultivating fear of people to deter livestock predation. Conflict deterrence is thus accomplished through practices explicitly aimed at the production of normalized relations of chronic fear between species, using real or threatened violence to discipline wolf behaviour.

Deterrence interventions based in fear are deeply rooted in underlying beliefs about the nature of wolves themselves, and the normalization of the human-wolf relationship of fear. Debates over wolf management are situated within a normative discourse in which wolves’ fear is not only “natural,” but “healthy,” a desirable state to be maintained by management. Interventions to induce fear (e.g., “do something to keep it afraid”) fall into a paradoxical appeal to the innate nature of that fear, in which human intervention becomes necessary to produce this so-called “natural” condition. For many ecological scientists and wildlife managers, this paradox is resolved by understanding livestock predation as the result of human transformation of wolves’ perceived risk-benefit trade-offs, tempting them with an easy new food source. From this perspective, fear-based discipline simply reinforces wolves’

“innate” fear, framing these efforts as a return to more “natural” conditions, albeit without taking the more extreme step of removing the livestock from the landscape (as advocated by some environmental advocates).

In this way “coexistence” between people, wolves, and livestock can also be framed as a natural condition—and thus a “win-win,” meeting human social and economic needs alongside conservation priorities. This stands in contrast to the idea that either wolves or livestock are out of place, as argued by livestock producers and conservationists respectively. In this context, the anthropocentric objectives of human management for a cascading series of desirable socioecological outcomes (reduced livestock predation leads to reduced social conflict leads to successful wolf conservation) become clouded by an appeal to nature: it becomes possible to say (and many do) that wolves should be afraid because it is simply the “natural” state of things, as opposed to recognizing the anthropocentric goal of reducing human-wolf-livestock conflict.

Washington’s ongoing, thorny debate over lethal and non-lethal approaches to wolf management is confused by multiple, largely unproven logics of “changing wolf behaviour,” amidst constant appeals to the “nature” of human-wolf-livestock fear dynamics. While many stakeholders talk about conflict mitigation in terms of creating fear in wolves, there is little clarity or scientific documentation about the mechanisms by which lethal and non-lethal tools create (or fail to create) fear, or their desired outcomes. For some stakeholders, lethal removal is an act of retribution, and efforts to change behaviour must be based on non-lethal approaches. For others, removal is the last-ditch tool for changing the behaviour of (by killing) a problem wolf that cannot be re-habituated, preventing future livestock predation. For still others, lethal removal is part of a broader suite of tools used to condition behaviour, based on the expectation that wolves recognize and assess risk (and pass that behaviour on to offspring, socially and/or genetically, creating a “wolf culture” that includes both more fearful behaviour and preferential predation on wild prey rather than livestock). The failure to distinguish between these different meanings of the concept of “changing wolf behaviour” makes it difficult for anyone to clearly articulate precisely what conflict reduction efforts

are intended to accomplish. Table 1 identifies multiple points of ambiguity and confusion about the management of fear dynamics, which are likely to lead to misunderstandings between managers and stakeholders in policy-making conversations. These questions provide a stepping-off point for further ecological and social research to inform the management of wildlife via fear, as well as a rich ground for discussion among policymakers and stakeholders applying fear-based deterrents on the ground.

Table 1

Management questions raised via an analysis of human-wolf-livestock conflict as the (socio)ecology of fear.

Is wolves' fear of humans as a species, or of particular stimuli/actions, and how do these relate to one another?

The socioecology of fear

As the Washington case shows, mitigating HWC involves managing complex socationatural dynamics that may lead to desired risk-avoidance adaptations in animal behaviour. We describe these dynamics as the “socioecology of fear,” which we offer as a conceptual framework for examining the complex interplay between ecological processes involving interspecies fear dynamics and human

Is the intent of fear-based interventions to achieve spatial separation of wolves and livestock, or to instill risk aversion to the act of attacking livestock?

The oft-repeated idea of “innate fear” of people, even as human actions work to reproduce that fear, may lead to the perception of animal behaviour as fixed or immutable, in contrast to wolves' actual behavioural plasticity and responsiveness to behavioural management. Recognizing wolves' ability to perceive, assess, and respond to various forms of risk, including stimuli such as non-lethal deterrents that simulate human presence, and perhaps the threat of lethal removal, will help clarify the purpose and use of fear-based tools and techniques. Use of such tools by managers working toward coexistence via manipulation of wolf behaviour should be understood in the social context of widespread ideas of human dominion over wildlife and the “naturalness” of the interspecies fear relationship.

Does “changing behaviour” refer simply to preventing or disrupting attacks on livestock, or to long-term aversive conditioning?

Efforts to manage wolves' fear should distinguish explicitly spatial approaches that create “landscapes of fear,” in which wolves avoid places they perceive as risky, from efforts to increase wolves' perception of targeting livestock in general as a high-risk activity. Such landscapes of fear are not only ecological phenomena, but intertwine with socio-political questions of land use for livestock grazing and producers' perceptions of risk vis-à-vis livestock predation.

Do fear-based interventions target only individual animals, or do wolves have social learning mechanisms by which deterrence effects are passed along?

Widespread but contested ideas about “teaching” wolves to behave frame deterrents as a disciplinary tactic that functions via permanent, chronic fear (rather than acute fear of a particular stimulus), which leads to learning new behaviours. This stands in contrast to the recognition that many tools must be rotated to maintain effectiveness and avoid habituation.

Does lethal removal of individuals have behavioural effects on other wolves, making its use part of the “applied ecology of fear”?

The idea that wolves in general “get the message” when deterrents are used, thereby changing “wolf culture” to prevent livestock predation in the long term, relies on unstated and untested assumptions about wolf social learning around anthropogenic risk. For instance, the premise of Washington's lethal policy, aiming to remove individuals “before behaviour is reinforced,” assumes wolf social learning of predation habits.

The premise of “lethal removal for fear,” in which removal arguably works via a behavioural rather than (or in addition to) a population-reduction mechanism, remains underexplored in the scientific literature (see Treves et al. 2019). Conceptualizing lethal removal in this way makes the above questions applicable to lethal as well as non-lethal deterrence tools, and to their use in tandem, with lethal removal creating the mortal risk to “back up” the threat of non-lethal tools, thereby laying the groundwork of underlying wolf fear on which non-lethals play.

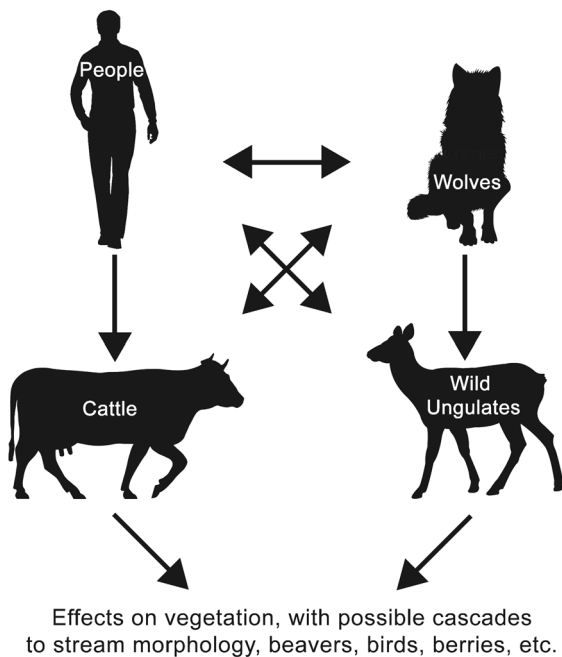


Figure 1

The socioecological “fear web” maps fear-based interspecies dynamics in human-wolf-livestock systems. The presence of a given species can be expected to lead to changes in the behaviour and/or space use of the affected species (Ripple et al. 2014; Miller and Schmitz 2019; Gaynor et al. 2021; Wilkinson et al. 2020).

social processes, including logics and assumptions *about* animal fear dynamics, in wildlife conflict management.

We intend the phrase “socioecology of fear” to evoke two related things. First, it refers in a general sense to the complex and multifaceted web of interspecies relationships, spanning humans and nonhumans (socioecological), in which fear dynamics between species play a significant role in mediating behaviour (that is, extending the “ecology of fear” concept to include human processes and interventions). While our case study emphasizes wolves’ fear of people, fear dynamics in human-wolf-livestock systems go in many directions: the presence of wolves generates fear among wild prey species, in livestock as potential prey, and perhaps most significantly, among people (Figure 1). The theme of “fear” thus slices across ecological and social relations, inviting deeper engagement and practices of interdisciplinary translation between scholars interested in

human-wildlife fear dynamics. Research topics that would benefit from critical re-framing via the “socioecology of fear” concept include: trophic cascades mediated by predator-prey fear; adaptations to predation risk by livestock producers (and even by livestock themselves, inasmuch as livestock anti-predator behaviour is also a socionatural phenomenon influenced by human interventions such as low-stress livestock handling techniques); the complex socio-cultural and political implications of human fears of predators or predator return; and of course, predator deterrence via fear-based techniques (our focus here). The socioecology of fear framework illuminates connections between changes in behaviour resulting from perceptions of increased risk in both humans and animals, rather than treating these respectively as the objects of separate and distinct social and biophysical sciences. In this way, we situate multi-species, multi-directional fear dynamics that play out in both physical and symbolic space at the heart of the issue of human-wildlife conflict and coexistence.

Second, the “socioecology of fear” refers to the production of animal fear itself (that is, self-protective behaviour in response to perceived anthropogenic risk) as a multispecies, socionatural process. In contrast to ideas that wolf fear of people is simply “innate” and immutable, we recognize fear as the product of interspecies relations, (re)produced through a history of (often-intentionally) threatening human-wolf encounters. Such encounters are shaped by human laws, policies, and social norms, which are in turn deeply influenced by social discourses about how wolves “should” behave (Figure 2). As we have shown in the case of Washington’s wolves, management practices to reduce wolf-livestock conflict by manipulating wolves’ fear are deeply entangled in discourses about “normal” wolf behaviours and human-wolf relations. Whether or not people believe that wolves belong (a long-contested, shifting question of social norms and cultural values across the western US), and related ideas about acceptable wolf behaviour, have had a significant influence on laws, policies, and practices of management, which in turn influence wolf behaviours (including predation). Human ideas about “innate” fear may therefore be used to justify the reproduction of that fear via particular kinds of normalized fear-inducing stimuli and interactions,

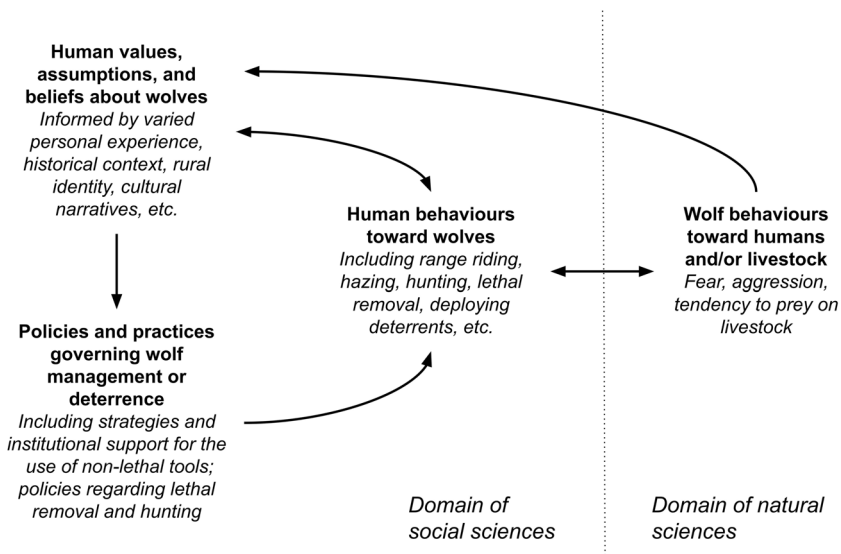


Figure 2

The material-discursive co-production of wolf behaviour with social assumptions, beliefs, policies, and practices via social norms for human-wolf interactions. These complex social dynamics and feedback loops influence human behaviours regarding wolf interactions, often with the effect of reinforcing wolves' fear of people.

perhaps even becoming self-fulfilling. This sense of the “socioecology of fear” offers a non-dualist way of examining the tension between “natural” animal behaviour and human efforts to “change” animal behaviours. By understanding animal fear as a socio-natural phenomenon, in which animal behaviour is co-produced by and with human social dynamics, we pay attention to the material effects of social discourses, which inform management decisions and interventions and thereby change wolf behaviour itself. Understanding animal fear as socionatural helps to clarify the mechanisms by which fear does or does not function, and toward what ends.

The “socioecology of fear” framework aligns with existing ecological studies of “applied ecology of fear” dynamics in managed ecosystems (Oriol-Cotterill et al. 2015; Miller and Schmitz 2019; Wilkinson et al. 2020; Gaynor et al. 2021). Importantly, though, not all human actions that affect animal fear dynamics are part of an intentional management effort. Actively “applied” interventions like hazing, scare devices, and lethal removal exist within a broader socio-cultural context characterized by socially reproduced fear between people and wolves. As an interdisciplinary boundary concept between wildlife ecology and critical geography, the

“socioecology of fear” framework offers attention to these complex social processes, connecting the ecological literature on conflict deterrence via the manipulation of fear dynamics with a perspective from critical human geography on how wolves, and the landscapes they share with people and livestock, are socially produced through the circulation of cultural discourses, norms, and values.

Conclusion

We hope that the framework of a “socioecology of fear” introduced through this case study will inform policy debates and improve management efforts around wolf-livestock conflict and coexistence on the ground. Management of human-wolf conflict—not just in Washington, but around the world—would benefit from a deeper examination of how coexistence relies on the (re)production and management of animal fear. As we have shown, fear is produced not only in specific animals and places for conflict deterrence, but as a normalized, chronic relationship between people and wolves via techniques such as hazing, hunting, and even lethal removal. Wolf fear is entangled with human social

dynamics, reproduced through interactions shaped by human social processes. Managing the socioecology of fear to mitigate conflict includes applied environmental interventions (e.g., deterrents), but also broader socionatural dynamics that produce normative interspecies relations of fear. In contrast to appeals to what is “natural” or “healthy” wolf behaviour—in which fear of people is taken for granted as the basis for conflict deterrence—the recognition of wolf fear as socionaturally-produced opens up questions around human-wolf dynamics that are otherwise sidestepped. Better recognizing the relationships between coexistence and management of wolf fear, and explicit articulation of the objectives and mechanisms by which this is done, should help clarify conflict management.

We further hope that our framework will open doors for scientific study, looking holistically at the web of fear dynamics between wolves, prey species, livestock, and people, and how those dynamics are produced and managed. Washington's wildlife and land managers, in collaboration with other stakeholders—including livestock producers, hunters, and environmental advocates—are attempting to manage complex and intertwined social and ecological dynamics in the absence of much scientific evidence on what works (cf. Martin 2021a). Many interventions are based on preconceptions and politics rather than rigorous empirical observation and testing, and a lack of clarity about the intent, use, and mechanisms of techniques that play upon wolf fear pervades the conversation. A critical research need is to better understand how both lethal and non-lethal deterrents work to change wolf behaviour, and how they can be deployed to effectively mitigate conflict and promote coexistence. Recognizing non-lethal measures as the manipulation of wolves' risk perception, we suggest taking an explicitly spatial approach to the study of non-lethal deterrence as the production of landscapes of fear and/or coexistence. For example, location data from collared wolves could be used to assess the effectiveness of non-lethal deterrents for altering wolves' use of space as the mechanism for reducing livestock predation. Research on animal movement in relation to deterrents on a landscape would fill an important gap in our understanding of their effectiveness and is well suited for further attention from critical physical geographers, integrating analysis of biophysical data on wolf movements with human social/power dynamics.

In addition to our focus on one specific fear dynamic—wolves' fear of people—we also hope that the socioecology of fear is a useful analytic for examining other relationships involving fear, including those more commonly situated on the “social side” of conservation. Humans' fears of wolves (including both emotional fear, and risk perception vis-à-vis the social and political-economic effects of wolf return) can also be affected, intentionally or not, by management policies—even as human dynamics are often rendered relatively static or intrinsic in the ecological literature. Human adaptations to the return of wolves, including questions of social tolerance, landscape permeability, and the social practices and dynamics required for coexistence (see Anderson 2021) are also part of the “socioecology of fear.” Building tolerance for wolf conservation may require reducing human fear of wolves even as mutual fear may also be the basis for landscapes of coexistence. Ongoing investments into tools and techniques to change wolf behaviour should be mirrored by efforts to understand the effects and effectiveness of such interventions on social dynamics.

While our focus here has been on wolves, our framework is applicable not only to other instances of HWC, but also to any dynamics where wildlife management is intertwined with social ideas about and manipulations of human and animal fear. In the context of socioecological feedback loops between interspecies fear relations, critical geography can be a key discipline to examine whether wildlife management efforts amount to “turning up or down the heat” on conflict (Treves et al. 2019, 3), recognizing that that question contains intertwined social and physical aspects.

Finally, we hope this paper will spark further cross-disciplinary conversation between wildlife ecologists, wildlife managers, scholars of the human dimensions of wildlife, and critical human and physical geographers, as well as biophysical and social scientists more generally. Our efforts to draw together insights from the ecological and social sciences aim to pave the way for further transdisciplinary collaboration in the practice of critical, integrative science on the socioecological dynamics of environmental management issues. Our paper's analytical approach was a demanding one. In thinking critically and openly across disciplinary boundaries, members of our authorship team were challenged to reconsider their own notions and

previous disciplinary trainings and perspectives regarding human-wolf fear dynamics. Our conversations revealed how basic questions like “what is fear?” and “what role does fear play in wolf management?” have multiple possible answers. In viewing wolf management through an irreducibly socioecological lens, we developed shared and more nuanced understandings. In this way, we take up the challenge posed by CPG to study the entangled social and biophysical dynamics of the Anthropocene, while also extending the scope of that challenge to deeply engage with the ongoing critical research already being conducted by wildlife scientists. Our work to develop the “socioecology of fear” as a boundary concept between critical geographers and ecologists contributes to the expansion of CPG as a project by developing an integrative approach to understanding the complex challenges of sharing space with wildlife. Perhaps even more importantly, we hope that our collaborative methodology and process of collective reflection and discussion between researchers trained in different disciplines, methods, and theories will be applied to the tremendous range of urgent socioecological challenges of the Anthropocene.

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