A review of fact claims about liberalizing the killing of wolves

Abstract

Predators play important, disproportionate roles in ecosystem health. Nevertheless, several governments recently initiated killing wolves non-selectively and in large numbers. Among the justifications, four fact claims are made for widespread wolf-killing: (1) increasing human safety, (2) raising human tolerance for surviving wolves, (3) preventing livestock loss, and (4) increasing wild ungulate populations. We reviewed the research into these claims and found scant evidence to support or refute claim (1). We found evidence to suggest equivocal or no effects of wolf-killing on the other three claims, or that killing wolves likely led to counter-productive outcomes. We also summarized reported benefits associated with wolves. We proposed several hypotheses to explain the use of unsupported claims and to explain expansion of wolf-killing recently. The three, non-mutually exclusive hypotheses for unsupported fact claims refer to trusted messengers are unreliable, misinterpreting scientific uncertainty, and interest group politics. Finally, we summarize explanations for the politics behind wolf-killing itself and the potential harms of unsupported claims on democratic processes.

Introduction

Worldwide consensus among ecologists provides strong evidence that top predators play important and disproportionate roles in ecosystem diversity and function (Estes et al. 2011). Nevertheless, in 2021 some state governments began pursuing aggressive efforts to reduce wolf populations through programs that include liberalized hunting, trapping, and hounding seasons, and efforts to incentivize killing (e.g.,

bounties). For example, Wisconsin reduced its wolf population by more than 27-33% in <1 year and then proposed a second wolf-hunt in the same year (Treves et al. 2021b; Treves & Louchouarn 2022); Idaho, Montana, and Wyoming planned to reduce their wolf populations by 90% or more (Brown & Samuels 2021).

These efforts represent a departure from policies of the recent past (Brown 2008) and (Bruskotter et al. 2010; Bruskotter et al. 2011), and raise the question: *why are states killing so many wolves*? Herein, we address justifications based on four fact claims that are commonly provided for permitting or encouraging an increase in the legal killing of wolves and other large carnivores: (1) increasing human safety, (2) raising human tolerance for surviving wolves, (3) preventing livestock loss, and (4) increasing wild ungulate populations. We evaluate the fact claims (hereafter 'claims') by reviewing the science on the social and ecological effects of these policies.

Increasing human safety

Wolves can, and in rare circumstances do, attack people (Linnell & Bjerke 2002; McNay 2002; Linnell et al. 2021). Thus, one justification governments provide for killing wolves has been to increase human safety. In Supplementary Materials 1, we present reports and statements by officials from the States of Michigan, Idaho, and Montana that show how claims about human safety have been used to raise fears or justify wolf-killing programs. Despite such warnings, zero humans have been killed by wolves in the Northern Rockies since their reintroduction.

In fact, wolves pose so little risk to people that aggressive killing programs proposed by U.S. states cannot lead to any further meaningful reduction of risk. Linnell and colleagues

(2002,2021) compiled documented reports of wolf attack on humans. The more recent study found evidence of 489 human victims of wolf attacks spanning 2002 to 2020 across the world, 26 of which were fatal, plus an equal number that were either too poorly documented to verify or "clearly" not caused by wolves, e.g., by dogs. Rabies explained 77% of the above attacks and 59% of fatalities, and the geographic distribution of attacks correlated with rabies incidence across Eurasia. These researchers classified 14% of attacks as "predatory," which accounted for 36% of the fatalities. The remaining attacks were classified as "provoked/defensive". They concluded, "In Europe and North America we only found evidence for 12 attacks (with 14 victims), of which 2 (both in North America) were fatal, across a period of 18 years. Considering that there are close to 60.000 wolves in North America and 15.000 in Europe, all sharing space with hundreds of millions of people it is apparent that the risks associated with a wolf attack are above zero, but far too low to calculate." Abstract, (Linnell et al. 2021).

Given the recovery of many wild prey populations eaten by wolves and wider acknowledgment of the problem associated with supplemental feeding of wild carnivores, the conditions for wolf attacks on people have accordingly diminished. Indeed, predatory attacks on people "…have been associated with a special set of environmental circumstances (absence of wild prey, heavily modified landscapes, high density of humans engaged in vulnerable activities) that are no longer present…" (Linnell & Alleau 2016) and consequently, "the risks of wolf attacks are currently very low" …" (Linnell & Alleau 2016).

Occasionally, wolf attacks may be precipitated by incidents of accidental or purposeful conditioning of wild wolves, whereby wolves learn to associate humans with food

or lose fear of people via habituation (McNay 2002). However, there is simply no evidence that such behavior is as widespread as it may have been before the 20th century (Linnell & Bjerke 2002).

Increasing human tolerance for wolves

Governments often claim that killing wolves increases public tolerance (or decreases intolerance) for wolves and their conservation (Refsnider 2009; Bruskotter et al. 2013; Treves & Bruskotter 2014; Chapron & Treves 2017b; Epstein et al. 2019). Yet, existing scientific evidence indicates that programs that liberalize the killing of wolves generally have not improved tolerance for wolves (Treves & Bruskotter 2014). The best evidence comes from the state of Wisconsin, where researchers assessed human attitudes using long-term, repeated measures (same individuals) before and after policy changes that liberalized wolf-killing or conversely, tightened protections for wolves. In total, three independent studies come from Wisconsin and Montana, (Supplementary Material 2).

Neither the Wisconsin nor Montana studies provide support for policies that seek to raise tolerance by expanding wolf-killing; but why? Policies may fail to affect tolerance if they are perceived by those who are intolerant as insufficient for reducing the risks they associate with wolves, or there may be a lag between the time the policy is enacted and subsequent changes in tolerance. The Wisconsin study shows a 12-year lag during which time tolerance declined in the face of such policies. These factors could explain both the growing intolerance witnessed in Wisconsin and the lack of change witnessed in the 2012 and 2018 studies in Montana.

A second way to examine the effect of policy on tolerance is to examine tolerance within a society across regions with different policies. To that end, Kaczensky et al. (Kaczensky et al. 2004) compared attitudes toward brown bears in two regions of Slovenia with different policies and bear damage levels. They found no difference in attitudes toward bears across regions. Similarly, Bruskotter et al. (2018) found no differences in attitudes towards wolves across three regions of the U.S. with different wolf management policies and histories (Bruskotter et al. 2018). Though a follow-up study found lower levels of tolerance in areas with wolves among certain sub-groups (i.e., hunters, ranchers; Carlson et al. 2020). These studies are generally consistent with the longitudinal research explored above in so much as both suggest that policy changes have little effect on attitudes.

Beyond the effect of policy, researchers have proposed a variety of mechanisms of attitude change both at the individual and societal level. e.g., (Ericsson et al. 2007; Karlsson & Sjöström 2007; Heberlein & Ericsson 2008; Bruskotter et al. 2017). A full review of these mechanisms is beyond the scope if this essay. However, a few findings are worth summarizing: (i) At the societal level, evidence indicates that the U.S. public at large has become substantially more positive towards wolves over the past half-century (George et al. 2016; Slagle et al. 2017); (ii) tolerance is strongly associated with changing social conditions (e.g., increased urbanization, education, income) that are often currently beneficial to carnivore conservation (Bruskotter et al. 2017; Manfredo et al. 2019; Manfredo et al. 2020; Manfredo et al. 2021). While these findings raise intriguing hypotheses, experimental studies, e.g., (Slagle et al. 2013) would be useful to better understand causal mechanisms.

Collectively, existing evidence indicates that tolerance is unaffected by management policies.

Beyond attitudes, some studies have assessed the effects of liberalized killing policies on tolerance more directly by examining hazard and incidence rates of poaching (illegal killing of wolves). Three populations of wolves showed substantial slow-downs in wolf population growth independent of the number of wolves killed legally each time wolf-killing was liberalized (Chapron & Treves 2016a, b, 2017a, b; Louchouarn et al. 2021). Slower population growth was inferred to reflect a hidden cause of mortality, poaching. Thus, some proportion of wolves killed illegally is observed directly, while another portion is observed indirectly, called "cryptic poaching" (Liberg et al. 2012). Failure to account for cryptic poaching – for example, discarding information on missing radio-collared wolves can have the effect of obscuring the dynamics of poaching and biasing population models (Treves et al. 2017; Santiago-Ávila et al. 2020b; Agan et al. 2021; Santiago-Ávila & Treves 2022).

Recent measurements of hazards and incidences of different endpoints for radio-collared wolves (i.e., death or disappearance) in gray wolves of Wisconsin and also the Mexican gray wolf subspecies in Arizona and New Mexico, reveal patterns of human poaching behavior also (Santiago-Ávila et al. 2020a; Louchouarn et al. 2021; Santiago-Ávila & Treves 2022); this research has been replicated in two additional populations (Michigan gray wolves and North Carolina red wolves), which are under review. Taken altogether, the ratio of reported poaching to cryptic poaching, and the sum of all poaching seems to vary with policy on hunting bears, deer, and coyotes; federal policy on wolf protection; and methods of censusing wolves. Although a detailed description of the previous work on

hazard and incidence of poaching for collared wolves is beyond our scope here, the inference for our present context is clear. Liberalizing wolf-killing did not raise tolerance when tolerance was measured in terms of poaching rates. Moreover, the latest studies follow new Open Science rules for registered reports that reduce publication biases (Sanders et al. 2017). That makes these studies the best available science by the standards of evidence accepted by the global scientific community.

The only credible peer-reviewed research suggesting poaching declined when legal wolf-killing was liberalized comes from Nordic countries (Suutarinen & Kojola 2017; Suutarinen & Kojola 2018; Liberg et al. 2020). However, the Scandinavian study has been questioned on statistical grounds of inappropriate survival analyses and inappropriate model specifications (Treves et al. 2020). It also did not account for non-breeding wolves nor for the finding from neighboring Finland that the more legal killing occurred, the lower the risk of poaching because wolves were removed legally before they could be removed illegally (Suutarinen & Kojola 2017; Suutarinen & Kojola 2018). Moreover, as Santiago-Ávila and Louchouarn pointed out, when the government preemptively removes wolves suspected of problems before they can be killed illegally, it's difficult to claim humans are exhibiting greater tolerance (Santiago-Ávila et al. 2020a; Louchouarn et al. 2021).

Collectively, studies support the hypothesis that governments send a signal to would-be poachers that wolves are low in value, or that the government needs the support of poachers to control wolf populations (Chapron & Treves 2016a). For example, Idaho recently contributed to funds to pay bounties for dead wolves (https://www.kmvt.com/2021/10/14/idaho-fish-game-reimburse-hunters-wolf-kills/) and in

153 years past, the same agency defied federal regulations protecting wolves by announcing
154 that they would no longer allow their own personnel to investigate reports of wolf poaching
155 https://www.spokesman.com/stories/2010/oct/19/idaho-pulling-back-on-wolves/. Thus,
156 we predict these policies have led and will continue to lower tolerance for wolves and
157 increase wolf killing.

158 **Killing wolves to prevent domestic animal losses**

159 One of the long-standing reasons for humans to kill wolves and other threatening
160 animals was to protect domestic animals, especially before secure fencing or structures
161 could separate them from wild animals (Treves & Bonacic 2016). For example, the U.S.
162 Department of Agriculture's Wildlife Services division was created largely to kill offending
163 animals (Robinson 2005; USDA APHIS 2015), and local jurisdictions also do this in many
164 countries (Bjorge & Gunson 1983; Fritts et al. 1992; Musiani et al. 2005; Epstein & Chapron
165 2018; Darpö 2020).

166 In the case of livestock protection, the best available evidence would come from
167 before-and-after comparisons of interventions with random sampling (Khorozyan 2021) and
168 other safeguards against research bias (Treves et al. 2016; Treves et al. 2019). No such
169 studies exist for wolf-killing. To date, research on lethal management of wolves ranges from
170 before-and-after comparisons without randomization to lower standard, correlational
171 analyses that leave numerous potentially confounding variables uncontrolled, e.g., (Krofel
172 et al. 2011; Fernández-Gil et al. 2016; Imbert et al. 2016).

173 Taken together, compiled research on the subject provides contradictory
174 conclusions. Lethal management of wolves can in some cases reduce risk and in others raise

175 risk or have no effect at all. Note that although Bradley et al. (Bradley et al. 2015) claimed
176 that lethal removal of an entire wolf pack would reduce livestock losses in that territory
177 thereafter, Santiago-Avila et al. (Santiago-Avila et al. 2018) were unable to reproduce their
178 methods let alone their results even after corresponding with the two lead authors.
179 Replicating the methods with improved transparency and sharing all the data for Michigan's
180 wolf control program, Santiago-Avila (Santiago-Avila et al. 2018) found risk increased for
181 cattle in neighboring townships after one or more wolves were killed at a nearby farm
182 within approximately 18 km. Therefore, the most rigorous research to date found that
183 targeted wolf-killing in Michigan, USA and wolf range, France (Santiago-Avila et al. 2018;
184 Grente 2021) did not increase livestock safety. In a minority of cases, wolf-killing appeared
185 effective for preventing recurrent livestock killing, but an equal or greater number of cases
186 appear to show an increase in livestock killing after lethal management.
187 In the latter studies and every review thus far published on the effectiveness of lethal
188 methods as a way to protect livestock, authors from over a dozen countries report
189 occasional counter-productive effects resulting in higher livestock losses after predator-
190 killing (Miller et al. 2016; Eklund et al. 2017; Lennox et al. 2018; Moreira-Arce et al. 2018;
191 van Eeden et al. 2018a; van Eeden et al. 2018b; Khorozyan & Waltert 2019; Treves et al.
192 2019; Khorozyan & Waltert 2020). Moreover, the effectiveness of non-lethal methods and
193 the standards of evidence used for their study are consistently higher than for lethal
194 methods (Supplementary Material 3).
195 Preventative, non-lethal methods are generally preferable over post hoc killing of
196 predators to avoid losses in the first place, and avoid government reimbursements (thus

197 potentially saving money and time). Payments for wolf damage have not been associated
198 with higher tolerance for wolves (Montag et al. 2003; Naughton-Treves et al. 2003; Treves
199 et al. 2009) and seem plagued by problems of accuracy or inequity (Agarwala et al. 2010;
200 López-Bao et al. 2017; Plumer et al. 2018). In general compensation payments can lead to a
201 decline in protective husbandry, which may distract from the more hazardous causes of
202 livestock mortality from disease, weather, and accidents (Allen & Sparkes 2001; Linnell &
203 Broseth 2003; Wallach et al. 2017).

204 Non-lethal methods have rarely led to counter-productive increases in livestock
205 losses due to wolves. For example, the non-lethal method (Foxlights®) has twice been
206 associated with increases in predation by carnivores other than wolves and so resulted in
207 more livestock losses under particular circumstances, i.e., effective against pumas but not
208 Andean foxes in Chile (Ohrens et al. 2019) and counter-productive against foxes in Australia
209 (Hall & Fleming 2021). Also, sub-lethal methods such as translocation often result in higher
210 mortality of the translocated wolves and perhaps recurrent livestock losses following such
211 removals (Fritts et al. 1985).

212 Methods that remove wolves diminish the benefits of wolves and may disrupt social
213 dynamics in ways that lead to additional livestock losses, thereby probably perpetuating a
214 cycle of killing that can spread livestock losses geographically (Santiago-Avila et al. 2018;
215 Grente 2021). Although eradication of all predators would, of course, protect livestock from
216 predation (Breitenmoser 1998; Riley et al. 2004; Nilsen et al. 2007), less drastic killing can
217 produce variable and unpredictable results. For example, lethal management that left
218 survivors of the same species in a majority of cases resulted in the same amount or higher

219 livestock losses as summarized above, as did lethal management that eliminated one
220 carnivore but left another species of predator. Furthermore, removing carnivores can
221 increase immigration of young animals into the area, which may result in higher levels of
222 predation on livestock (Peebles et al. 2013). Removing apex carnivores may also result in
223 higher abundances of subordinate carnivores (Newby & Brown 1958; Crooks & Soulé 1999).
224 Those and other mesopredator interactions suggest that eradications of large predators like
225 the wolves will have varied effects on other animals including domestic ones (Krofel et al.
226 2007; Prugh et al. 2009; Allen et al. 2016; Minnie et al. 2016; Newsome et al. 2017; Nattrass
227 et al. 2019; Elbroch et al. 2020). For example, the eradication of the Tasmanian thylacine
228 *Thylacinus cynocephalus*) seems to have left niche vacancies for the smaller dingoes (*Canis*
229 *familiars dingo*) and red foxes (*Vulpes vulpes*) to become the dominant livestock predators
230 of Australia and Tasmania (Greentree et al. 2000; Allen & Sparkes 2001; Sillero-Zubiri et al.
231 2007; Newsome et al. 2017). Or consider the expansion of range by coyotes *Canis latrans* in
232 the wake of extermination of red (*C. rufus)* and gray wolves *(C. lupus*) across many U.S.
233 States and Canadian provinces (Gompper 2002; Hinton et al. 2016), with associated
234 complaints of losses from sheep owners, for example (Murray Berger 2006).
235 The counter-productive increases in property damage or losses of game after lethal
236 management have been reported anecdotally for over half a century (Newby & Brown 1958;
237 Haber 1996). Such anecdotes have been corroborated by systematic scientific studies of
238 coyote-killing. Virtually all (99%) of the predation by coyotes on sheep was done by mated
239 pairs with pups to feed, so most lethal management kills coyotes that have not killed and
240 will not kill sheep (Knowlton et al. 1999); also see (Wallach et al. 2017) for counter-

241 productive effects of killing dingoes on an Australian cattle ranch, and more recently by
242 systematic scientific studies of wolf killing in several countries as summarized above. Given
243 that societies globally have outlawed programs of eradication of native predators (Ripple et
244 al. 2014; Ripple et al. 2017a; Ripple et al. 2017b), we conclude from the scientific evidence
245 that non-lethal methods have a better record both in terms of effectiveness and higher
246 standards of scientific research (Treves et al. 2019). Non-lethal methods will also safeguard
247 the diverse benefits of wolves we summarize below.

248 **Killing wolves to increase wild ungulate abundance**

249 Relatedly, governments have for a century or more justified killing wolves as a
250 means to increase hunting opportunity for ungulates, such as elk and deer (Leopold
251 1933 reprinted 1986, 1949; Theberge & Gauthier 1985) (Harbo & Dean 1983). Wolves
252 are capable of reducing wild ungulate populations (Ripple & Beschta 2012); however the
253 effect of wolves on ungulates depends on other factors, such as ungulate vulnerability
254 driven by winter severity (Vucetich & Peterson 2009; Peterson et al. 2014), local primary
255 productivity (Melis et al. 2009), the abundance of local ungulates relative to their
256 carrying capacity (Ballard et al. 2001) , the diversity of the local carnivore guild and
257 potential for multiple ungulate predators (Griffin et al. 2011) and the abundance of
258 alternative prey (i.e. apparent competition; (Wittmer et al. 2005). A rigorous, recent
259 meta-analysis of the outcomes of carnivore removal on ungulate populations
260 determined that predator removals resulted in increased juvenile survival and
261 recruitment, but equivocal effects on ungulate abundance, which should be the metric
262 that determines success (Clark & Hebblewhite 2021). In a meta-analysis of female elk

survival from western North America, (Brodie et al. 2013) concluded that the best way to increase ungulate abundance was instead to decrease human harvest rather than predators.

The exceptions to these general patterns are predator effects on small ungulate populations. Wolf predation can harm rare ungulates via apparent competition. However, the underlying circumstances that lead to apparent competition are generally created by anthropogenic influences on ecosystems. Even intensive wolf-killing may not affect such rare ungulates, e.g. endangered woodland caribou; (Wittmer et al. 2005). For example, (Hervieux et al. 2014) found killing 841 wolves over 7 years, which equated to a 45% reduction in mid-winter wolf abundance, was insufficient to increase the population growth rate of endangered woodland caribou in their study area.

Reports from all U.S. states with wolf populations indicate that opportunities to hunt wild ungulates have not been diminished by increased wolf populations. Indeed, recent records from Idaho, Montana, and Wyoming indicate that the number of elk killed by hunters in recent years is stable to increasing in those three states, as are elk populations. Data from Idaho, Montana and Wyoming were summarized here: https://extension.colostate.edu/topic-areas/people-predators/wolves-big-game-and-hunting-8-001/. In Wisconsin, the forty-five-year period from 1975-2020, the state deer population grew from 600,000 to 1.61 million (https://www.researchgate.net/figure/Wisconsin-Prehunt-and-Posthunt-Deer-Population-Estimates-and-Goal-1960-2010-Source_fig5_324135601), while the wolf population grew from zero to 1034 in late winter counts (Wiedenhoeft et al. 2020). Also,

hunters took 200,000 deer in the 1980s as compared to 500-600,000 in the 2000s (https://www.researchgate.net/figure/Wisconsin-Prehunt-and-Posthunt-Deer-Population-Estimates-and-Goal-1960-2010-Source_fig5_324135601).

Collectively, these data and the scientific studies suggest that the positive effects of killing wolves on wild ungulate abundance are negligible.

A mismatch between goals of wolf-killing and approaches taken

The above four claims can also be viewed as the objectives for liberalized killing of wolves. Objectives 1 and 3 (increasing human safety, preventing livestock loss), and perhaps objective 2 as well (raising human tolerance for wolves) are driven by negative interactions with individual wolves or wolf packs, rather than populations of wolves. For this reason, the best strategy to mitigate the costs of these few wolves on human communities is their targeted removal rather than liberalized killing aimed at reducing the entire wolf population across wide areas. Should liberalized killing succeed in reducing the wolf population, but miss the wolves responsible for livestock loss or human safety concerns, the conflicts driving claims 1-3 are likely to continue unabated and calls for more killing may persist or escalate.

Hypothetically, liberalized killing to reduce the wolf population is a better match for the fourth objective, increasing ungulate populations and hunting opportunities at large scales. Nevertheless, reducing wolves to increase ungulate abundance rarely works for any but the smallest ungulate populations for the reasons we describe in the previous section, and because ungulate abundance is primarily explained by weather and primary productivity (White 2008), rather than apex carnivores.

The benefits and costs of coexistence between humans and wolves

Just public policy maximizes the benefits minus the costs associated with management interventions. Thus, having considered the various risks (i.e., to human safety, livestock, and wild ungulates), we find it appropriate to detail potential benefits. In general, research shows that majorities of people appreciate wolves and other carnivores, e.g., cougars, coyotes (Bruskotter et al. 2018; Manfredo et al. 2020), and that people report both financial and non-financial benefits of wildlife (Slagle et al. under review)(Kellert 1985; Williams et al. 2002; Naughton-Treves et al. 2003). One subpopulation of wolves in Yellowstone National Park, for example, has produced net financial benefits beyond the boundaries of the park (Duffield & Neher 1996; Duffield et al. 2008). Preliminary findings suggest that counties hosting one or more packs of wolves report fewer deer-vehicle collisions and reduced human injuries and fatalities, saving millions of dollars (Raynor et al. 2021). That result grew out of an awareness that wolves were changing the behavior of deer and elk and some evidence of broader ecosystem effects of wolves.

Many studies suggest wolves can also benefit ecosystems through their effects on their prey and associated ecological communities. For example, wolves may reduce the incidence or transmission of zoonotic and wildlife diseases (Wild et al. 2011; Tanner et al. 2019), increase scavenger diversity (Smith et al. 2003), and reduce deer damage to vegetation (Martin et al. 2020). Regarding the latter, rare understory plants fared better near the center of wolf pack territories (Callan et al. 2013), and forests were more biodiverse and mature, had higher tree volumes and regeneration rates, and resisted non-native plant invasions in the presence of wolves (Waller & Reo 2018). Though such effects may vary with conditions, research suggests wolves enhance biodiversity via direct and

329 indirect pathways that begin with limiting ungulate herbivory, or by altering the competition
330 between prey species. Scientific consensus holds that top predators generally play such roles
331 (Estes et al. 2011; LaBarge et al. 2022), but we would highlight the need for formal
332 comparisons between the benefits associated with apex carnivores and the economic costs
333 long attributed to wolves (Gilbert et al. 2021).

334 Lethal management of wolves is not cost-free, and so we need to weigh the use of
335 public funds for wolf killing against the benefits minus the costs of maintaining wolves, or
336 expanding their ranges. It is not at all clear that aggressive killing of wolves will significantly
337 reduce the real or perceived risks associated with living with wolves. Conversely, it is likely
338 that the large-scale killing of wolves as proposed by some governments will substantially
339 diminish the benefits associated with their presence.

340 **Why do governments cite weak or unsupported claims for aggressively killing wolves?**

341 The scarcity of scientific evidence for the claims made to justify killing wolves leads
342 to an obvious question: why are governments making such claims? To begin with, three
343 non-exclusive explanations seem plausible.

344 1. Policy makers may believe their wolf-killing claims are true. For example, the
345 trusted messenger theory of communication sciences predicts that messages are believed
346 or embraced more quickly, and that they shape behavior more effectively when delivered
347 by a trusted messenger (Dunwoody 2007; Kinzig et al. 2013). Further, people tend to filter
348 information and retain what supports their existing belief and value systems (Kinzig et al.
349 2013; Bruskotter et al. 2016; Antonelli & Perrigo 2018; Byerly et al. 2018; Kinka & Young
350 2019). That propensity has led at times to predator management that conflates value-

based decisions with evidence-informed decisions (Mitchell et al. 2018; Koot et al. 2020; Treves et al. 2021a). If a trusted messenger delivers inaccurate information, policy-makers may find themselves weighing apparently contradictory science and then selecting that which they trust more based on the identity of the messengers or their inherent biases and beliefs on the subject. This hypothesis is partly dissatisfying because it leaves unanswered why the trusted messengers intentionally or unintentionally persuaded policy-makers with unsupported claims.

2. Policy-makers advancing wolf-killing with unsupported claims may not know the scientific evidence or may think the science is unclear enough to support their claims. We view this as unlikely because peer-reviewed scientific evidence has been presented repeatedly to debunk the claims via public comments, litigation, and official federal peer reviews, since 2013 (Bruskotter et al. 2013; Treves et al. 2021a). For example, the litigation and federal agency peer reviews have addressed some or all of the claims surrounding wolf protection and wolf-killing in Wisconsin, the northern Rocky Mountains, and nationwide (Naughton-Treves et al. 2003; Atkins 2019) and (Humane Society of the U.S. 2014. 2017, 1:13-cv-00186-BAH Doc 52, Western Watersheds Project 2018, 1:17-cv-00206-BLW Doc 22-3). Furthermore, the suggestion that scientific uncertainty about the four claims among scientists left policy with equivocal recommendations, has a prerequisite of transparent debate between experts with diverse views. We know of no such review or debate. In general, North American hunt management plans lack the hallmarks of independent review and transparency, as revealed by a close reading of 666 such plans and a survey of the agency staff responsible for carrying out such plans (Artelle et al. 2018a; Artelle et al.

373 2018b). Therefore, it seems implausible that policy-makers believed there was sufficient
374 scientific uncertainty to support their claims.

375 3. Policy-makers may know their claims are unlikely to be true, and these policies
376 instead reflect internal values or external pressures acting on policy decisions, e.g.,
377 (Chapron & Lopez-Bao 2014; Darimont et al. 2018). This possibility finds circumstantial
378 support in several other claims made by current governments to justify wolf-killing. One
379 such value-based claim is that hunters, trappers, and hound-hunters should be given
380 additional hunting opportunities. The claim is that governments are creating more
381 opportunities for these people via aggressive wolf policies. Although such justifications are
382 not entirely in the domain of facts that scientists can evaluate, they are dubious on their
383 face because of a logical flaw. Reducing carnivore abundance comes at the expense of
384 carnivore hunters, who lose hunting opportunities over the long term (Mitchell et al. 2018).

385 Why then are governments promoting aggressive killing programs? Recent research
386 documenting the relationship between voting for the reintroduction of wolves (a Colorado
387 ballot measure in the 2020 election) and presidential voting may provide insights into the
388 internal and external pressures that may be acting on policy makers and their constituents.
389 That study found the strongest predictor of voting for wolf restoration at the precinct level
390 was the proportion that voted for the Democratic candidate for president (Ditmer et al.
391 2022). specifically, as Democratic voting increased, support for restoration increased (β =
392 0.60 to 0.66 [95% CI]). Similarly, other research shows that political party affiliation and
393 socio-political identity were strong predictors of attitudes toward carnivore policies in
394 other jurisdictions (Hamilton et al. 2020; van Eeden et al. 2021) however, see (Carlson et al.

2020). Collectively, these data suggest that the general issue of how to manage wolves has become politicized precisely at a time when the U.S. electorate is extremely polarized, politically (McCoy et al. 2018). In such environments, the wolf policies pursued by governments may not serve any legitimate wildlife management purpose.

Rather, because wolf-killing policies align with the positions of interest groups that are themselves aligned with a conservative agenda (e.g., agricultural groups, hunting groups), and because these groups traditionally hold great sway with wildlife policy-making bodies, there is little risk for decision-makers in supporting such policies, e.g., (Chapron & Lopez-Bao 2014). In contrast, pursuit of policies viewed as supportive of wolves may carry substantial risk for policy-makers. Indeed, research from psychology has long shown how pressure to conform to group settings can powerfully influence decision-makers (Asch 1951; Asch 1952; Asch 1956). Moreover, the dynamics of multiple individual decision-makers acting in concert may complicate the policy analysis.

Regardless of the underlying causal explanation for why governments are using unsupported claims, the effect is corrosive on a constitutional democracy like that of the U.S., particularly one whose environmental assets are held in trust for current and future generations. Reliance on unlikely or false factual claims undermines both public policy and the authorities from which it emanates. As public trustees for wildlife under U.S. common law (Geer 1896, 161 U.S. 519, Hughes 1979, 441 U.S. 322, U.S. 1989, 710 F. Supp. 1286), elected and appointed government officials have a professional, legal, and ethical duty to account transparently with the most sophisticated methods for assets held in trust for current and future generations. Use of unlikely or false claims is undesirable for sound,

representative public policy and is therefore clearly undesirable for a constitutional democracy because such conduct would mislead the sovereign public.

References

Agan SW, Treves A, Willey EL. 2021. Estimating poaching risk for the critically endangered wild red wolf (Canis rufus). PLoS One **16**:e0244261.

Agarwala M, Kumar S, Naughton-Treves L, Treves A. 2010. Paying for wildlife. Compensation policy and practice for wolves in Solapur, India and Wisconsin, USA. Biological Conservation **143**:2945-2955.

Allen BL, Geoff Lundie-Jenkins, Neil D. Burrows, Richard M. Engeman, Peter J.S. Fleming, Leung LK-P. 2016. Does lethal control of top-predators release mesopredators? A re-evaluation of three Australian case studies. Ecological Management & Restoration **15**:193-195.

Allen LR, Sparkes EC. 2001. The effect of dingo control on sheep and beef cattle in Queensland. Journal of Applied Ecology **38**:76-87.

Antonelli A, Perrigo A. 2018. The pitfalls of taking science to the public. Science **359**:283.

Artelle KA, Reynolds JD, A. T, Walsh JC, C. PP, Darimont CT. 2018a. Distinguishing science from “fact by assertion” in natural resource management. Science Advances (eLetter) **4**:eaao0167.

Artelle KA, Reynolds JD, A. T, Walsh JC, Paquet PC, Darimont CT. 2018b. Hallmarks of science missing from North American wildlife management. Science Advances **4**:eaao0167.

Asch SE. 1951. Effects of group pressure upon the modification and distortion of judgment in Guetzkow H, editor. Groups, leadership and men. Carnegie Press., Pittsburgh, PA.

Asch SE. 1952. Group forces in the modification and distortion of judgments. Pages 450–501 in Asch SE, editor. Social psychology. Prentice-Hall, Inc., New York.

Asch SE. 1956. Studies of independence and conformity: I. A minority of one against a unanimous majority. Psychological Monographs: General and Applied **70**:1–70.

Atkins. 2019. Summary Report of Independent Peer Reviews for the U.S. Fish & Wildlife Service Gray Wolf Delisting Review. Atkins, https://www.fws.gov/endangered/esa-library/pdf/Final%20Gray%20Wolf%20Peer%20Review%20Summary%20Report_053119.pdf.

Ballard WB, Lutz D, Keegan TW, Carpenter LH, deVos Jr. JC. 2001. Deer-predator relationships: a review of recent North American studies with emphasis on mule and black-tailed deer. Wildlife Society Bulletin **29**:99–115.

Bjorge RR, Gunson JR. 1983. Wolf predation of cattle on the Simonette River pastures in northwestern Alberta. Pages 106-111 in Carbyn LN, editor. Wolves in Canada and Alaska: their status, biology and management. Canadian Wildlife Service, Edmonton.

Bradley EH, Robinson HS, Bangs EE, Kunkel K, Jimenez MD, Gude JA, Grimm T. 2015. Effects of Wolf Removal on Livestock Depredation Recurrence and Wolf Recovery in Montana, Idaho, and Wyoming. Journal of Wildlife Management **79**:1337–1346.

Breitenmoser U. 1998. Large predators in the Alps: The fall and rise of man's competitors. Biological Conservation **83**:279-289.

462 Brodie J, et al. 2013. Relative influence of human harvest, carnivores, and weather on adult
463 female elk survival across eastern North America. Journal of Applied Ecology **50**:295–
464 305.
465 Brown M. 2008. Three states seek to retain control of wolves. Associated Press.
466 Brown M, Samuels I. 2021. US states look to step up wolf kills, pushed by Republicans.
467 Associated Press, https://apnews.com/article/donald-trump-wildlife-animals-lakes-
468 billings-5eda7213f2cbec6c3d46897e74dddf80, March 7, 2021.
469 Bruskotter JT, Enzler S, Treves A. 2011. Rescuing wolves from politics: wildlife as a public
470 trust resource. Science **333**:1828-1829.
471 Bruskotter JT, J, . A. Vucetich, M. J. Manfredo, G. R. Karns, C. Wolf K, N. H. Carter, J. V. López-
472 Bao, G. Chapron, Gehrt SD, Ripple WJ. 2017. Modernization, Risk, and Conservation
473 of the World's Largest Carnivores. BioScience **67**:646-655.
474 Bruskotter JT, Toman E, Enzler SA, Schmid RH. 2010. Gray wolves not out of the woods yet.
475 Science **327**:30.
476 Bruskotter JT, Vucetich JA, Enzler S, Treves A, Nelson MP. 2013. Removing protections for
477 wolves and the future of the U.S. Endangered Species Act (1973) Conservation
478 Letters **7**:401-407.
479 Bruskotter JT, Vucetich JA, Slagle KM, Berardo R, Singh AS, Wilson RS. 2018. Support for the
480 U.S. Endangered Species Act over time and space: Controversial species do not
481 weaken public support for protective legislation. Conservation Letters**;e12595**:1-7.
482 Bruskotter JT, Vucetich JA, Wilson RS. 2016. Of bears and biases: scientific judgment and the
483 fate of Yellowstone's grizzlies. The Conversation **June 21, 2016**.

484 Byerly H, Balmford A, Ferraro PJ, Wagner CH, Palchak E, Polasky S, Ricketts TH, Schwartz AJ,
485 Fisher B. 2018. Nudging pro-environmental behavior: evidence and opportunities.
486 Frontiers in Ecology and the Environment:doi:10.1002/fee.1777.
487 Callan R, Nibbelink NP, Rooney TP, Wiedenhoeft JE, Wydeven A. 2013. Recolonizing wolves
488 trigger a trophic cascade in Wisconsin (USA). Journal of Ecology **101**:837–845
489 Carlson SC, Dietsch AM, K.M. S, J.T. B. 2020. The VIPs of Wolf Conservation: How Values,
490 Identity, and Place Shape Attitudes Toward Wolves in the United States. Frontiers in
491 Ecology and Evolution **8**:6.
492 Chapron G, Lopez-Bao J. 2014. Conserving Carnivores: Politics in Play. Science **343**:1199-
493 1200.
494 Chapron G, Treves A. 2016a. Blood does not buy goodwill: allowing culling increases
495 poaching of a large carnivore. Proceedings of the Royal Society B **283**:20152939.
496 Chapron G, Treves A. 2016b. Correction to 'Blood does not buy goodwill: allowing culling
497 increases poaching of a large carnivore'. Proceedings of the Royal Society B **Volume**
498 **283**:20162577.
499 Chapron G, Treves A. 2017a. Reply to comment by Pepin et al. 2017. Proceedings of the
500 Royal Society B **2016257**:20162571.
501 Chapron G, Treves A. 2017b. Reply to comments by Olson et al. 2017 and Stien 2017.
502 Proceedings of the Royal Society B **284**:20171743.
503 Clark TJ, Hebblewhite M. 2021. Predator control may not increase ungulate populations in
504 the future: A formal meta-analysis. Journal of Applied Ecology **58**:812-824.

505 Crooks KR, Soulé ME. 1999. Mesopredator release and avifaunal extinctions in a fragmented
506 system. Nature **400**:563-566.
507 Darimont CT, Paquet PC, Treves A, Artelle KA, Chapron G. 2018. Political populations of large
508 carnivores. Conservation Biology **32**:747–749.
509 Darpö J. 2020. The Last Say? Comment on cjeus Judgement in the Tapiola Case (C-674/17).
510 Journal for European Environmental & Planning Law **17**:117-130.
511 Ditmer MA, Niemiec RM, Wittemyer G, Crooks KR. 2022. ocio-ecological drivers of public
512 conservation voting: restoring gray wolves to Colorado, USA. Ecological Applications,
513 e2532. . ocio-ecological drivers of public conservation voting: restoring gray wolves
514 to Colorado, USA:e2532. .
515 Duffield JW, Neher CJ. 1996. Economics of wolf recovery in Yellowstone National Park.
516 Transactions of the North American Wildlife and Natural Resources Conference
517 **61**:285-292.
518 Duffield JW, Neher CJ, Patterson DA. 2008. Wolf recovery in Yellowstone: Park visitor
519 attitudes, expenditures, and economic impacts. George Wright Forum **25**:13-19.
520 Dunwoody S. 2007. The challenge of trying to make a difference using media messages
521 Pages 89-104 in Moser SC, and Dilling L, editors. Creating a climate for change.
522 Cambridge University Press, Cambridge.
523 Eklund A, López-Bao JV, Tourani M, Chapron G, Frank J. 2017. Limited evidence on the
524 effectiveness of interventions to reduce livestock predation by large carnivores.
525 Scientific Reports **7**:2097 | DOI:2010.1038/s41598-41017-02323-w.

526 Elbroch L, Ferguson J, Quigley H, Craighead D, Thompson D, Wittmer H. 2020. Reintroduced
527 wolves and hunting limit the abundance of a subordinate apex predator in a multi-
528 use landscape. Proceedings of the Royal Society B **287**:e20202202.
529 Epstein Y, Chapron G. 2018. The Hunting of Strictly Protected Species: The Tapiola Case and
530 the Limits of Derogation under Article 16 of the Habitats Directive. European Energy
531 and Environmental Law Review **June**:78-87.
532 Epstein Y, Lopez-Bao J, Trouwborst A, Chapron G. 2019. EU Court: Science must justify future
533 hunting. Science **366**:961.
534 Ericsson G, Bostedt G, Kindberg J. 2007. Wolves as a symbol of people's willingness to pay
535 for large carnivore conservation. Society and Natural Resources **21**:294-309.
536 Estes JA, et al. 2011. Trophic Downgrading of Planet Earth. Science **333**:301-306.
537 Fernández-Gil A, Naves J, Ordiz As, Quevedo M, Revilla E, Delibes M. 2016. Conflict Misleads
538 Large Carnivore Management and Conservation: Brown Bears and Wolves in Spain.
539 PLoS ONE **11**:e0151541.
540 Fritts SH, Paul WJ, Mech LD, Scott DP 1992. Trends and management of wolf-livestock
541 conflicts in Minnesota. US Fish and Wildlife Service, Resource Publication 181,
542 Washington, DC.
543 Fritts SH, W. J. Paul, Mech LD. 1985. Can relocated wolves survive? Wildlife Society Bulletin
544 **13**:459-463.
545 George KA, Slagle KM, Wilson RS, Moeller SJ, Bruskotter JT. 2016. Changes in attitudes
546 toward animals in the United States from 1978 to 2014. Biological Conservation
547 **201**:237–242.

548 Gilbert S, Carter N, Naidoo R. 2021. Predation services: Quantifying societal effects of
549 predators and their prey Frontiers in Ecology and the Environment **19**:292– 299.
550 Gompper ME. 2002. Top carnivores in the suburbs? Ecological and conservation issues raised
551 by colonization of North-eastern North America by coyotes BioScience **52**:185-190.
552 Greentree C, Saunders G, McLeod L, Hone J. 2000. Lamb predation and fox control in south-
553 eastern Australia. Journal of Applied Ecology **37**:935-943.
554 Grente O. 2021. résentation des objectifs et de la méthodologie de la thèse sur l'efficacité
555 des tirs de loup et la gestion adaptative du loup, menée conjointement par l'ONCFS
556 et le CEFE. OFB, Direction de la recherche et de l'appui scientifique, Unité Prédateurs,
557 animaux déprédateurs et exotiques, Équipe Loup et Lynx, Gières, France.
558 Griffin KA, et al. 2011. Neonatal mortality of elk driven by climate, predator phenology and
559 predator community composition. Journal of Animal Ecology **80**:1246–1257.
560 Haber GC. 1996. Biological, conservation, and ethical implications of exploiting and
561 controlling wolves. Conservation Biology **10**:1068-1081.
562 Hall K, Fleming PA. 2021. In the spotlight: can lights be used to mitigate fox predation in a
563 free-range piggery? Applied Animal Behaviour Science **2**:105420.
564 Hamilton LC, J. E. Lambert, L. A. Lawhon, J. Salerno, Hartter J. 2020. Wolves are back:
565 Sociopolitical identity and opinions on management of Canis lupus. Conservation
566 Scienceand Practice **2**:e213.
567 Harbo SJ, jr., Dean FC. 1983. Historical and current perspectives on wolf management in
568 Alaska. Pages 51-64 in Carbyn LN, editor. Wolves in Canada and Alaska: Their Status,
569 Biology and Management. Canadian Wildlife Service, Edmonton.

570 Heberlein TA, Ericsson G. 2008. Public attitudes and the future of wolves Canis lupus in
571 Sweden. Wildlife Biology **14**:391-394.
572 Hervieux D, Hebblewhite M, Stepnisky D, Bacon M, Boutin S. 2014. Managing wolves (Canis
573 lupus) to recover threatened woodland caribou (Rangifer tarandus caribou) in
574 Alberta. Canadian Journal of Zoology **93**:245–247.
575 Hinton JW, Brzeski KE, Rabon DR, Chamberlain MJ. 2016. Effects of anthropogenic mortality
576 on critically endangered red wolf Canis rufus breeding pairs: implications for red wolf
577 recovery. Oryx **doi:10.1017/S0030605315000770**.
578 Imbert C, Caniglia R, Fabbri E, Milanesi P, Randi E, Serafini M, Torretta E, Meriggi A. 2016.
579 Why do wolves eat livestock? Factors influencing wolf diet in northern Italy.
580 Biological Conservation **195**:156-168.
581 Kaczensky P, Blazic M, Gossow H. 2004. Public attitudes towards brown bears (Ursus arctos)
582 in Slovenia. Biological Conservation **118**:661–674.
583 Karlsson K, Sjöström M. 2007. Human attitudes towards wolves, a matter of distance.
584 Biological Conservation **137**:610-616.
585 Kellert SR. 1985. Public perceptions of predators, particularly the wolf and coyote. Biological
586 Conservation **31**:167-189.
587 Khorozyan I. 2021. Defining practical and robust study designs for interventions targeted at
588 terrestrial mammalian predators. Conservation Biology **in press**:1–11.
589 Khorozyan I, Waltert M. 2019. How long do anti-predator interventions remain effective?
590 Patterns, thresholds and uncertainty. Royal Society Open Science **6**.

591 Khorozyan I, Waltert M. 2020. Variation and conservation implications of the effectiveness
592 of anti-bear interventions. Scientific Reports **10,**:15341.
593 Kinka D, Young JK. 2019. The tail wagging the dog: positive attitude towards livestock
594 guarding dogs do not mitigate pastoralists' opinions of wolves or grizzly bears.
595 Palgrave Communications **5**.
596 Kinzig AP, et al. 2013. Social Norms and Global Environmental Challenges: The Complex
597 Interaction of Behaviors, Values, and Policy. Bioscience **63**:164–175.
598 Knowlton FF, Gese EM, Jaeger MM. 1999. Coyote depredation control: An interface between
599 biology and management. Journal of Range Management **52**:398-412.
600 Koot S, Hebinck P, Sullivan S. 2020. Science for Success—A Conflict of Interest? Researcher
601 Position and Reflexivity in Socio-Ecological Research for CBNRM in Namibia. Society &
602 Natural Resources:1-18.
603 Krofel M, Černe R, Jerina K. 2011. Effectiveness of wolf (Canis lupus) culling as a measure to
604 reduce livestock depredations. Acta Silvae et Ligni **95**:11-22.
605 Krofel M, Giannatos G, Ćirović D, Stoyanov S, Newsome TM. 2007. Golden jackal expansion
606 in Europe: a case of mesopredator release triggered by continent-wide wolf
607 persecution? . Hystrix **28**:9-15.
608 LaBarge L, Evans M, Miller J, Cannataro G, Hunt C, Flemming E, Elbroch L. 2022. Pumas as
609 ecological brokers: a review of their biotic relationships. Mammal Review. .
610 Lennox RJ, Gallagher AJ, Ritchie EG, Cooke SJ. 2018. Evaluating the efficacy of predator
611 removal in a conflict-prone world. Biological Conservation **224**:277-289.

612 Leopold A 1933 reprinted 1986. Game Management. Scribner 1933 , University of Wisconsin
613 Press 1986, New York and Madison, Wisconsin.
614 Leopold A 1949. A Sand County Almanac: And Sketches Here and There. Oxford University
615 Press.
616 Liberg O, Chapron G, Wabakken P, Pedersen HC, Hobbs NT, Sand H. 2012. Shoot, shovel and
617 shut up: cryptic poaching slows restoration of a large carnivore in Europe.
618 Proceedings of the Royal Society of London Series B **270**:91-98.
619 Liberg O, Suutarinen J, Åkesson M, Andrén H, Wabakken P, Wikenros C, Sand H. 2020.
620 Poaching-related disappearance rate of wolves in Sweden was positively related to
621 population size and negatively to legal culling. Biological Conservation **243**.
622 Linnell JD, Alleau J. 2016. Predators that kill humans: myth, reality, context and the politics of
623 wolf attacks on people. Pages 357-371 in Angelici FM, editor. Problematic wildlife.
624 Springer Link.
625 Linnell JD, Kovtun E, Rouart I. 2021. Wolf attacks on humans: an update for 2002–2020.
626 Norwegian Institute for Nature Research.
627 Linnell JDC, Bjerke T. 2002. Frykten for ulven. En tverrfaglig utredning. (Fear of wolves: an
628 interdisciplinary study.). NINA oppdragsmelding **722**:1-110.
629 Linnell JDC, Broseth H. 2003. Compensation for large carnivore depredation of domestic
630 sheep. Carnivore Damage Prevention News **6**:11-13.
631 López-Bao JV, Frank J, Svensson L, Åkesson M, Langefors As. 2017. Building public trust in
632 compensation programs through accuracy assessments of damage verification
633 protocols. Biological Conservation **213**:36–41.

634 Louchouarn NX, Santiago-Ávila FJ, Parsons DR, Treves A. 2021. Evaluating how lethal
635 management affects poaching of Mexican wolves Open Science **8 (registered**
636 **report)**:200330.
637 Manfredo mJ, Salerno J, Sullivan L, Berger J. 2019. For US wildlife management, social
638 science needed now more than ever. BioScience **69**:960-961.
639 Manfredo MJ, Teel TL, Berl RE, Bruskotter JT, Kitayama S. 2021. Social value shift in favour of
640 biodiversity conservation in the United States. Nature Sustainability **4**:323–330.
641 Manfredo MJ, Teel TL, Don Carlos AW, Sullivan L, Bright AD, Dietsch AM, Bruskotter J, Fulton
642 D. 2020. The changing sociocultural context of wildlife conservation. Conservation
643 Biology.
644 Martin J-L, Chamaillé-Jammes S, Waller DM. 2020. Deer, wolves, and people: costs, benefits
645 and challenges of living together. Biological Reviews **95**:782-801.
646 McCoy J, Rahman T, Somer M. 2018. Polarization and the global crisis of democracy:
647 Common patterns, dynamics, and pernicious consequences for democratic polities.
648 American Behavioral Scientist **62**:16-42.
649 McNay ME. 2002. Wolf-Human Interactions in Alaska and Canada: A Review of the Case
650 History. Wildlife Society Bulletin **30**:831-843.
651 Melis C, et al. 2009. Predation has a greater impact in less productive environments:
652 Variation in
653 roe deer, Capreolus capreolus, population density across Europe. Global Ecology and
654 Biogeography **18**:724–734.

655 Miller J, Stoner K, Cejtin M, Meyer T, Middleton A, Schmitz O. 2016. Effectiveness of
656 Contemporary Techniques for Reducing Livestock Depredations by Large Carnivores.
657 Wildlife Society Bulletin **40**:806-815.
658 Minnie L, Gaylard A, Kerley G. 2016. Compensatory life-history responses of a mesopredator
659 may undermine carnivore management efforts Journal of Applied Ecology **53**:379-
660 387.
661 Mitchell MS, Cooley H, Gude JA, Kolbe J, Nowak JJ, Proffit KM, Sells SN, Thompson M. 2018.
662 Distinguishing values from science indecision making: setting harvest quotas for
663 mountain lions in Montana. Wildlife Society Bulletin **42**:13-21.
664 Montag J, Patterson ME, Sutton B. 2003. Political & Social Viability of Predator
665 Compensation Programs in the West. Missoula, MT.
666 Moreira-Arce D, Ugarte CS, Zorondo-Rodríguez F, Simonetti JA. 2018. Management Tools to
667 Reduce Carnivore-Livestock Conflicts: Current Gap and Future Challenges. Rangeland
668 Ecology & Management.
669 Murray Berger K. 2006. Carnivore-livestock conflicts: Effects of subsidized predator control
670 and economic correlates on the sheep industry Conservation Biology **20**:751-761.
671 Musiani M, Muhly T, Cormack Gates C, Callaghan C, Smith ME, Tosoni E. 2005. Seasonality
672 and reoccurrence of depredation and wolf control in western North America. Wildlife
673 Society Bulletin **33**:876-887.
674 Nattrass N, Conradie B, Stephens J, Drouilly M. 2019. Culling recolonizing mesopredators
675 increases livestock losses: Evidence from the South African Karoo. Ambio.

676 Naughton-Treves L, Grossberg R, Treves A. 2003. Paying for tolerance: The impact of
677 livestock depredation and compensation payments on rural citizens' attitudes toward
678 wolves. Conservation Biology **17**:1500-1511.
679 Newby F, Brown R. 1958. A new approach to predator management in Montana. Montana
680 Wildlife **8**:22-27.
681 Newsome TM, et al. 2017. Top predators constrain mesopredator distributions. Nature
682 Communications **8**:15469.
683 Nilsen EB, Milner-Gulland EJ, Schofield L, Mysterud A, Stenseth NC, Coulson T. 2007. Wolf
684 reintroduction to Scotland: public attitudes and consequences for red deer
685 management Proceedings of the Royal Society B **274**:995-1002.
686 Ohrens O, Bonacic C, Treves A. 2019. Non-lethal defense of livestock against predators:
687 Flashing lights deter puma attacks in Chile. Frontiers in Ecology and the Environment
688 **17**:32-38.
689 Peebles K, Wielgus RB, Maletzke BT, Swanson ME. 2013. Effects of Remedial Sport Hunting
690 on Cougar Complaints and Livestock Depredations. PLoS ONE **8**:e79713.
691 Peterson RO, Vucetich JA, Bump JK, Smith DW. 2014. Trophic cascades in a multicausal
692 world: Isle Royale and Yellowstone. Annual Review of Ecology, Evolution, and
693 Systematics **45**:325-345.
694 Plumer L, Talvi Tn, Männil P, Saarma U. 2018. Assessing the roles of wolves and dogs in
695 livestock predation and suggestions for mitigating human-wildlife conflict and
696 conservation of wolves. Conservation Genetics **https://doi.org/10.1007/s10592-017-**
697 **1045-4**.

698 Prugh LR, Stoner CJ, Epps CW, Bean WT, Ripple WJ, Laliberte AS, Brashares JS. 2009. The Rise
699 of the Mesopredator. Bioscience **59**:779-791.
700 Raynor JL, Grainger CA, Parker DP. 2021. Wolves make roadways safer, generating large
701 economic returns to predator conservation. Proceedings of the National Academy of
702 Sciences **118**:e2023251118.
703 Refsnider R. 2009. The Role of the Endangered Species Act in Midwest Wolf Recovery. Pages
704 311-330 in Wydeven AP, Van Deelen TR, and Heske EJ, editors. Recovery of gray
705 wolves in the Great Lakes region of the United States: An endangered species success
706 story. Springer, New York.
707 Riley SJ, Nesslage GM, Maurer BA. 2004. Dynamics of early wolf and cougar eradication
708 efforts in Montana: implications for conservation. Biological Conservation **119**:575-
709 579.
710 Ripple WJ, Beschta RL. 2012. Large predators limit herbivore densities in northern forest
711 ecosystems. European Journal of Wildlife Research **58**:733-742.
712 Ripple WJ, et al. 2017a. Conserving the World's Megafauna and Biodiversity: The Fierce
713 Urgency of Now. Bioscience **67**:197–200.
714 Ripple WJ, et al. 2014. Status and ecological effects of the world's largest carnivores. Science
715 **343**:1241484.
716 Ripple WJ, Wolf C, Newsome TM, Galetti M, Alamgir M, Crist E, Mahmoud MI, Laurance WF,
717 and 15 ssfc. 2017b. World Scientists' Warning to Humanity: A Second Notice.
718 Bioscience **67**:1026–1028.
719 Robinson M 2005. Predatory Bureaucracy. University of Colorado Press, Boulder, CO.

720 Sanders J, et al. 2017. Transparency and openness in science. Royal Society Open Science
721 **https://doi.org/10.1098/rsos.160979**.
722 Santiago-Ávila FJ, Chappell RJ, Treves A. 2020a. Liberalizing the killing of endangered wolves
723 was associated with more disappearances of collared individuals in Wisconsin, USA.
724 Scientific Reports **10**:13881.
725 Santiago-Avila FJ, Cornman AM, Treves A. 2018. Killing wolves to prevent predation on
726 livestock may protect one farm but harm neighbors. PLoS ONE **13**:e0189729
727 Santiago-Ávila FJ, Treves A. 2022. Poaching of protected wolves fluctuated seasonally and
728 with non-wolf hunting. Scientific Reports **12**:e1738
729 Santiago-Ávila FJ, Treves A, Lynn WSec-a. 2020b. Just preservation, trusteeship and
730 multispecies justice. Animal Sentience: Response to Commentary on Treves et al. on
731 Just Preservation **27**:393-409.
732 Sillero-Zubiri C, Sukumar R, Treves A. 2007. Living with wildlife: the roots of conflict and the
733 solutions. Pages 266-272 in MacDonald D, and Service K, editors. Key Topics in
734 Conservation Biology. Oxford University Press, Oxford.
735 Slagle K, Zajac R, Bruskotter J, Wilson R, Prange S. 2013. Building tolerance for bears: A
736 communications experiment. Journal of Wildlife Management **77**:863-869.
737 Slagle KM, Bruskotter JT, Singh AS, Schmid RH. 2017. Attitudes toward predator control in
738 the United States: 1995 and 2014. Journal of Mammalogy **8**:7-16.
739 Smith DW, Peterson RO, Houston DB. 2003. Yellowstone after wolves. Bioscience **53**:330-
740 340.

741 Suutarinen J, Kojola I. 2017. Poaching regulates the legally hunted wolf population in
742 Finland. Biological Conservation **215**:11–18.
743 Suutarinen J, Kojola I. 2018. One way or another: predictors of wolf poaching in a legally
744 harvested wolf population. Animal Conservation **21**:–9.
745 Tanner E, A. White, P. Acevedo, A. Balseiro, Marcos J, Gortázar C. 2019. Wolves contribute to
746 disease control in a multi-host system. Scientific Reports **7940**.
747 Theberge JB, Gauthier DA. 1985. Models of wolf-ungulate relationships: When is wolf control
748 justified? Wildlife Society Bulletin **13**:449-458.
749 Treves A, Artelle KA, Darimont CT, Parsons DR. 2017. Mismeasured mortality: correcting
750 estimates of wolf poaching in the United States. Journal of Mammalogy **98**:1256–
751 1264.
752 Treves A, Bonacic C. 2016. Humanity's dual response to dogs and wolves. Trends in Ecology
753 and Evolution TREE **31**:489-491.
754 Treves A, Bruskotter JT. 2014. Tolerance for predatory wildlife. Science **344**:476-477.
755 Treves A, Jurewicz RL, Naughton-Treves L, Wilcove D. 2009. The price of tolerance: Wolf
756 damage payments after recovery. Biodiversity and Conservation **18**:4003–4021.
757 Treves A, Krofel M, McManus J. 2016. Predator control should not be a shot in the dark.
758 Frontiers in Ecology and the Environment **14**:380-388.
759 Treves A, Krofel M, Ohrens O, Van Eeden LM. 2019. Predator control needs a standard of
760 unbiased randomized experiments with cross-over design. Frontiers in Ecology and
761 Evolution **7** 402-413.

762 Treves A, Louchouarn NX. 2022. Uncertainty and precaution in hunting wolves twice in a
763 year. PLoS One **in press**.
764 Treves A, Louchouarn NX, Santiago-Ávila F. 2020. Modelling concerns confound evaluations
765 of legal wolf-killing. Biological Conservation
766 **https://doi.org/10.1016/j.biocon.2020.108643**:108643.
767 Treves A, Paquet PC, Artelle KA, Cornman AM, Krofel M, Darimont CT. 2021a. Transparency
768 about values and assertions of fact in natural resource management. Frontiers in
769 Conservation Science: Human-Wildlife Dynamics **2**:e631998.
770 Treves A, Santiago-Ávila FJ, Putrevu K. 2021b. Quantifying the effects of delisting wolves
771 after the first state began lethal management. PeerJ **9**: e11666.
772 USDA APHIS. 2015. Wildlife Services Enabling Legislation. U.S. Department of Agriculture
773 Animal and Plant Health Inspection Services.
774 van Eeden LM, Crowther MS, Dickman CR, Macdonald DW, Ripple WJ, Ritchie EG, Newsome
775 TM. 2018a. Managing conflict between large carnivores and livestock. Conservation
776 Biology: doi: 10.1111/cobi.12959.
777 van Eeden LM, et al. 2018b. Carnivore conservation needs evidence-based livestock
778 protection. PLOS Biology **l 16**.
779 van Eeden LM, S. Rabotyagov, M. Kather, C. Bogezi, A. J. Wirsing, Marzluff J. 2021. Political
780 affiliation predicts public attitudes toward gray wolf (Canis lupus) conservation and
781 management. Conservation Science and Practice **3**:e387.
782 Vucetich JA, Peterson RO. 2009. Wolf and moose dynamics on Isle Royale. Pages 35-48 in
783 Wydeven AP, Van Deelen TR, and Heske EJ, editors. Recovery of gray wolves in the

784 Great Lakes region of the United States: An endangered species success story.
785 Springer, New York.
786 Wallach AD, Ramp D, O'Neill AJ. 2017. Cattle mortality on a predator-friendly station in
787 central Australia. Journal of Mammalogy **98**:45-52.
788 Waller DM, Reo NJ. 2018. First Stewards: Ecological Outcomes of Forest and Wildlife
789 Stewardship by Indigenous peoples of Wisconsin, USA. Ecology and Society **23**:45-60.
790 White T. 2008. The role of food, weather and climate in limiting the abundance of animals.
791 Biological Reviews **83**:227–248.
792 Wiedenhoeft JE, Walter S, Gross M, Kluge N, McNamara S, Stauffer G, Price-Tack J, Johnson
793 R. 2020. Wisconsin gray wolf monitoring report 15 April 2019 through 14 April 2020
794 in MANAGEMENT BOW, editor. Wisconsin Department of Natural Resources,
795 Madison, Wisconsin.
796 Wild MA, Hobbs T, Graham MS, Miller MW. 2011. The role of predation in disease control: A
797 comparison of selective and nonselective removal on prion disease dynamics in deer.
798 Journal of Wildlife Diseases **47**:78-93.
799 Williams CK, Ericsson G, Heberlein TA. 2002. A quantitative summary of attitudes toward
800 wolves and their reintroduction (1972-2000). Wildlife Society Bulletin **30**:575-584.
801 Wittmer HU, Sinclair ARE, Mclellan BN. 2005. The role of predation in the decline and
802 extirpation of woodland caribou. Oecologia **144**:257-267.
803
804