Saturday, May 3, 2025

Public comment on “Notice of Intent to Prepare an Environmental Impact Statement for Grizzly Bear Damage Management in Montana” Docket No. APHIS-2025-0004.

By A. Treves, PhD, University of Wisconsin-Madison

The overarching goals of this public comment are to update APHIS on the latest best available science, discuss issues of research integrity pursuant to the National Academies of Science (2017) “Fostering Integrity in Research” white paper https://nap.nationalacademies.org/read/21896/chapter/1, and explain why killing predators demands a benefits minus costs analysis which would be biased without considering the many benefits of predators to ecosystem health and human society.

I have studied predator-prey ecology since 1992. I have published 107 peer-reviewed scientific articles on that and related topics of conservation and scientific integrity. My research on wolves was cited by the Wisconsin state legislature in 2025.

Goal outline

1. I update the agency on the scientific literature on predator management for use in the public administrative record. I address the issue of the scientific controversy and uncertainty surrounding the effectiveness of lethal control for all predators and especially "preventative" Predator Damage Management (PDM, also sometimes called “proactive” or “preemptive” PDM).
2. I address the need for experimental randomized controls (especially in PDM), three principles of research integrity, and the hierarchy of strength of inference.
3. Killing predators reduces the benefits of coexistence between predators and people

Goal 1. **I update the agency on the scientific literature on predator management for use in the public administrative record. I address the issue of the scientific controversy and uncertainty surrounding the effectiveness of lethal control for all predators and especially "preventative" predator Damage Management (PDM, also sometimes called “proactive” or “preemptive” PDM).**

I divided the literature into 5 subsections (a–d) below

a. Studies of non-lethal methods published after 2018
b. Carnivore removal either as preemptive, proactive, preventive PDM or reactively (bears omitted, see below for a section specifically on lethal management of bears)
c. Scientific debate is equivocal about the effectiveness of lethal management of bears
d. Robust and reliable study design for inferring the effect of interventions against wildlife damage

Annotated lists of references for subsections a–d:

a. Studies of non-lethal methods published after 2018

Khorozyan I, Waltert M. How long do anti-predator interventions remain effective? Patterns, thresholds and uncertainty. Royal Society Open Science. 2019;6(9):e190826. 10.1098/rsos.190826.

Iliopoulos Y, Astaras C, Lazarou Y, Petridou M, Kazantzidis S, Waltert M. Tools for co-existence: Fladry corrals efficiently repel wild wolves (*Canis lupus*) from experimental baiting sites. Wildl Res. 2019;46(6):484–98. https://doi.org/10.1071/WR18146 .

Bruns A, Waltert M, Khorozyan I. The effectiveness of livestock protection measures against wolves (*Canis lupus*) and implications for their co-existence with humans. Global Ecology and Conservation. 2020;21:e00868. https://www.sciencedirect.com/science/article/pii/S2351989419306225 .

Beckmann JP, Lackey CW, Berger J. Evaluation of deterrent techniques and dogs to alter behaviour of "nuisance" black bears. Wildl Soc Bull. 2004;32:1141-6.

Hall K, Fleming PA. In the spotlight: Can lights be used to mitigate fox predation in a free-range piggery? Appl Anim Behav Sci. 2021;2:105420. https://doi.org/10.1016/j.applanim.2021.105420. https://doi.org/10.1016/j.applanim.2021.105420 .

Huygens OC, van Manen FT, Martorello DA, Hayashi H, Ishida J. Relationships between Asiatic black bear kills and depredation costs in Nagano Prefecture, Japan. Ursus. 2004;15(2):197-202.

Louchouarn NX, Treves A. Low-stress livestock handling protects cattle in a five-predator habitat. PeerJ. 2023;11:e14788. http://doi.org/10.7717/peerj.14788 .

McManus J, Dickman A, Gaynor D, Smuts B, Macdonald D. Dead or alive? Comparing costs and benefits of lethal and non-lethal human-wildlife conflict mitigation on livestock farms. Oryx. 2015;49(4):687-95.

Although the following articles pertain to leopards, consider evaluating these methods for pumas and cattle

Khorozyan I, Siavash G, Mobin S, Soofi M, Waltert M. Studded leather collars are very effective in protecting cattle from leopard (*Panthera pardus*) attacks. Ecological Solutions and Evidence. 2020;1(1):e12013. https://besjournals.onlinelibrary.wiley.com/doi/full/

10.1002/2688-8319.12013#:~:text=We%20conclude%20that%20studded%20leather,other%20felids%20over%20livestock%20depredation.

Naha D, Chaudhary P, Sonker G, Sathyakumar S. Effectiveness of non-lethal predator deterrents to reduce livestock losses to leopard attacks within a multiple-use landscape of the Himalayan region. PeerJ. 2020;8:e9544. http://doi.org/10.7717/peerj.9544 .

McManus J, Faraut L, Couldridge V, van Deventer J, Samuels I, Cilliers D, et al. Assessment of leopard translocations in South Africa. Frontiers in Conservation Science. 2022;3:943078. 10.3389/fcosc.2022.943078.

Nolte DL, Veenendaal TJ, Ziegltrum GJ, Fersterer P. Bear behaviour in the vicinity of supplemental feeding stations in western Washington. Western Black Bear Workshop 2001;7:106-11.

Ohrens O, Bonacic C, Treves A. Non-lethal defense of livestock against predators: Flashing lights deter puma attacks in Chile. Front Ecol Environ. 2019;17(1):32-8. 10.1002/fee.1952.

1Okemwa B, Gichuki N, Virani M, Kanya J, Kinyamario J, Santangeli A. Effectiveness of led lights on bomas in protecting livestock from predation in southern Kenya. Conservation Evidence. 2018;15:39-42.

Lichtenfeld LL, Trout C, Kisimir EL. Evidence-based conservation: Predator-proof bomas protect livestock and lions. Biodiversity Conservation. 2015;24:483-91.

Rossler ST, Gehring TM, Schultz RN, Rossler MT, Wydeven AP, Hawley JE. Shock collars as a site-aversive conditioning tool for wolves. Wildl Soc Bull. 2012;DOI: 10.1002/wsb.93.

Young JK, Sarment W. Can an old dog learn a new trick? : Efficacy of livestock guardian dogs at keeping an apex predator away from people. Biol Conserv. 2024; 292:110554. https://doi.org/10.1016/j.biocon.2024.110554 .

Ziegltrum GJ. Efficacy of black bear supplemental feeding to reduce conifer damage in western Washington J Wildl Manage. 2004;68(3):470-4.

Davidson-Nelson SJ, Gehring TM. Testing fladry as a nonlethal management tool for wolves and coyotes in Michigan. Human–Wildlife Interactions. 2010;4(1):87-94. https://doi.org/10.26077/mdky-bs63 .

Hawley JE, Gehring TM, Schultz RN, Rossler ST, Wydeven AP. Assessment of shock collars as nonlethal management for wolves in Wisconsin. J Wildl Manage. 2009;73(4):518–25.

Jacobs B, Kareiva P, Schachtschneider C. The expanding use and effectiveness of nonlethal methods for mitigating wolf-cattle conflict. Rangelands. 2025. 10.1016/j.rala.2025.02.002.

Stone SA, Breck SW, Timberlake J, Haswell PM, Najera F, Bean BS, et al. Adaptive use of nonlethal strategies for minimizing wolf–sheep conflict in Idaho. J Mammal. 2017;98(1):33-44. ttps://doi.org/10.1093/jmammal/gyw188.

Young JK, Draper J, Breck S. Mind the gap: Experimental tests to improve efficacy of fladry for nonlethal management of coyotes. Wildl Soc Bull. 2019:1-7. 10.1002/wsb.951.

Zarco-González MM, Monroy-Vilchis O. Effectiveness of low-cost deterrents in decreasing livestock predation by felids: A case in central Cexico. Anim Conserv. 2014;17:371–8.

Overview of section 1(a)
The field of predator management continues to have better quality individual studies of non-lethal methods than lethal methods, because of the adoption of the randomized, controlled design in the studies of non-lethal methods to protect property. For that gold-standard study design (see section 1(c) below), numerous studies are showing the effectiveness of human supervision of domestic animals: fladry against wolves or coyotes, livestock guarding dogs in a variety of circumstances, and several other non-lethal methods. Foxlights® have a mixed record of success, so they demand particularly careful design and monitoring lest domestic animal losses rise. Other methods such as painting eye-spots, electric fences, protective collars, etc., have scantier records of study thus far, so these too would benefit from additional robust studies of their effectiveness for US predator management.

All studies and reviews agree that the design, installation and maintenance of any deterrent (lethal or non-lethal) is essential to its effectiveness. Failure to adhere to peer-reviewed published methods describing the design, installation, or maintenance of non-lethal PDM cannot constitute an appropriate test of the method and should not be characterized as such. Unfortunately, I have heard and observed numerous instances in which improper design, installation, or maintenance is evident in the field installation of fladry or design of range riding, but an APHIS staff member characterizes the method as not effective. Such inappropriate communications betray a bias by APHIS staff, when they have not accurately summarized the peer-reviewed research on a non-lethal method and do not make clear the critical design elements for effectiveness, see NAS (2017) principles of research integrity in goal 1(d) below.

b. Carnivore removal either as preemptive, proactive, preventive PDM or reactively (see below for a section specifically on lethal management of bears)

Elbroch L, Treves A. Why might removing carnivores maintain or increase risks for domestic animals? Biol Conserv. 2023;283:110106. 10.1016/j.biocon.2023.110106. https://reader.elsevier.com/reader/sd/pii/S0006320723002070?token=46E6016BAC8F57713332D78DA55134F2A34CC2E20E4A2635C16370C47100C9E8132F3DB5FACBD944C85E02AA0A52114D&originRegion=us-east-1&originCreation=20230504162631.

Treves A, Elbroch LM. Does killing wild carnivores raise risk for domestic animals? Wild Felid Monitor. 2022. https://www.wildfelid.org/monitor.php.

Treves A, Bruskotter JT, Elbroch LM. Evaluating fact claims accompanying policies to liberalize the killing of wolves. In: Proulx G, editor. Wildlife conservation & management in the 21st century– issues, solutions, and new concepts. Canada: Alpha Wildlife Publications; 2024. p. 159-80. https://faculty.nelson.wisc.edu/treves/pubs/Evaluate%20fact%20claims%20about%20killing%20wolves_2024.pdf .

Nattrass N, Conradie B, Stephens J, Drouilly M. Culling recolonizing mesopredators increases livestock losses: Evidence from the South African karoo. Ambio. 2019;49(6):1222–31. https://www.ncbi.nlm.nih.gov/pubmed/31679108 .

Kutal M, Duľa M, Selivanova AR, López-Bao JV. Testing a conservation compromise: No evidence that public wolf hunting in Slovakia reduced livestock losses. Conservation Letters. 2024;17(1). 10.1111/conl.12994.

Nadler Valency R, Shavit G, Preiss-Bloom S, Margalit S, Ben-Ami D, Dayan T. Effects of lethal and non-lethal wolf (*Canis lupus*) management. Ecological Solutions and Evidence. pre-print in review;ESO-25-04-096. https://www.researchgate.net/publication/390528210_Effects_of_Lethal_and_Non-lethal_Wolf_Canis_lupus_Management?channel=doi&linkId=67f20296e8041142a16a35cf&showFulltext=true .

Preiss-Bloom S, Shamon H, Ben-Ami D, Dayan T. Landscape of risk: Responses of grey wolves to lethal control in a mosaic landscape. European Journal of Wildlife Research. 2025;71(2). 10.1007/s10344-025-01910-x.

Šuba J, Žunna A, Bagrade G, Done G, Ornicāns A, Pilāte D, et al. Does wolf management in Latvia decrease livestock depredation? An analysis of available data. Sustainability. 2023;15(11). 10.3390/su15118509.

Fernández-Gil A, Naves J, Ordiz As, Quevedo M, Revilla E, Delibes M. Conflict misleads large carnivore management and conservation: Brown bears and wolves in Spain. PLoS One. 2016;11(3):e0151541. 10.1371/journal.pone.0151541.

Krofel M, Černe R, Jerina K. Effectiveness of wolf (*Canis lupus*) culling as a measure to reduce livestock depredations. Acta Silvae et Ligni. 2011;95:11-22.

Santiago-Avila FJ, Cornman AM, Treves A. Killing wolves to prevent predation on livestock may protect one farm but harm neighbors. PLoS One. 2018;13(1):e0189729 / 10.1371/journal.pone.0189729. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0189729 .

Santiago-Avila F, Cornman A, Treves A. Correction: Killing wolves to prevent predation on livestock may protect one farm but harm neighbors. PLoS One. 2018;13(2):e0209716. https://doi.org/10.1371/journal.pone.0209716 .

Although the below is a pre-print at the time of public comment, I recommend the agency contact atreves@wisc.edu for the published version by the time you read this comment
Treves A, Ben-Ami D, Cornman AM, Dul'a M, Khorozyan I, Krofel M, et al. Inadequate evidence that removing wolves prevents domestic animal losses. in review 2025. https://uwmadison.box.com/s/zkf1k0bxzgb4lye6n3zuszakmny1uull

McManus J, Faraut L, Couldridge V, van Deventer J, Samuels I, Cilliers D, et al. Assessment of leopard translocations in South Africa. Frontiers in Conservation Science. 2022;3:943078. 10.3389/fcosc.2022.943078.

Allen LR, Sparkes EC. The effect of dingo control on sheep and beef cattle in Queensland. J Appl Ecol. 2001;38:76-87.

Allen BL, West P. Influence of dingoes on sheep distribution in Australia. Aust Vet J. 2013;91(7):261-7. https://www.ncbi.nlm.nih.gov/pubmed/23782018 .

Allen BL, Allen LR, Engeman RM, Leung LK-P. Sympatric prey responses to lethal top-predator control: Predator manipulation experiments. Frontiers in Zoology 2014;11(56):1-30. http://www.frontiersinzoology.com/content/11/1/56 .

Allen LR. Wild dog control impacts on calf wastage in extensive beef cattle enterprises. Animal Production Science. 2014;54(2). 10.1071/an12356.

Allen LR. Demographic and functional responses of wild dogs to poison baiting. Ecol Manage Restor. 2015;16(1):58-66. 10.1111/emr.12138.

Allen BL, Geoff Lundie-Jenkins, Neil D. Burrows, Richard M. Engeman, Peter J.S. Fleming, Leung LK-P. Does lethal control of top-predators release mesopredators? A re-evaluation of three Australian case studies. Ecol Manage Restor. 2016;15(3):193-5. doi: 10.1111/emr.12118.

Allen BL, Hampton JO. Minimizing animal welfare harms associated with predation management in agro-ecosystems. Biol Rev Camb Philos Soc. 2020. 10.1111/brv.12601. https://www.ncbi.nlm.nih.gov/pubmed/32302055 .

Allen LR, Barnes TS, Fordyce G, McCosker KD, McGowan MR. Reproductive performance of northern Australia beef herds. 8. Impact of rainfall and wild dog control on percentage fetal and calf loss. Animal Production Science. 2020;63(4):388-94. 10.1071/an19430.

Clark TJ, Hebblewhite M. Predator control may not increase ungulate populations in the future: A formal meta-analysis. J Appl Ecol. 2021;58(4):812-24. 10.1111/1365-2664.13810. https://doi.org/10.1111/1365-2664.13810 .

Conner MM, Jaeger MM, Weller TJ, McCullough DR. Effect of coyote removal on sheep depredation in northern California. J Wildl Manage. 1998;62(2):690-9.

Greentree C, Saunders G, McLeod L, Hone J. Lamb predation and fox control in south-eastern Australia. J Appl Ecol. 2000;37:935-43.

(b) Although some research and summaries of literature on removal (lethal or non-lethal translocation) have accumulated, the science is generally less advanced than for non-lethal research because so few randomized, controlled studies of removal have been conducted, peer-reviewed, and published transparently and reproducibly. Note I separated out the equivocal scientific debate about the effectiveness of killing bears (see 1(c) below).

When it comes to removal of wolves, the preponderance of the evidence indicates wolf killing commonly fails to protect domestic animals, in a minority of cases, achieves the desired result, and also in a minority of cases has the undesirable, counter-productive effects of elevating domestic animal losses (see a meta-analysis of 5 studies from 5 countries submitted for publication as Treves et al. 2025 pre-print ; contact atreves@wisc.edu for the latest status of this pre-print).

Furthermore, I call your attention to the randomized, controlled studies of fox and dingo poisoning to protect sheep and cattle in Australia. These studies reveal the very small effect (if any) and the very narrow conditions under which dingo-killing might protect sheep or calves. These studies have set the standard for studying lethal PDM and help to explain why effects are mixed and often undesirable.

Note that, to meet the scientific standards of the international scientific community studying PDM, researchers should measure the most common, potentially confounding variables (temporal autocorrelation between domestic animal losses in time 1 and time 2; and treatment bias between losses preceding removal of predators and the number of predators removed). I explain these issues further in section 1(d) below. Without such exacting control over confounding variables, the researchers must study a large sample of independent subjects (herds or grazing areas) using a randomized, controlled study. The field has advanced beyond APHIS approach to evaluating the effectiveness of methods.

c. Scientific debate is equivocal about the effectiveness of lethal management of bears

Khorozyan I, Waltert M. Variation and conservation implications of the effectiveness of anti-bear interventions. Scientific Reports. 2020; 10:15341. 10.1098/rsos.190826. https://www.nature.com/articles/s41598-020-72343-6 .

Raithel JD, Reynolds-Hogland MJ, Koons DN, Carr PC, Aubry LM. Recreational harvest and incident-response management reduce human–carnivore conflicts in an anthropogenic landscape. J Appl Ecol. 2017;54:1552-62. 10.1111/1365-2664.12830.

Northrup JM, Howe EJ, Inglis J, Newton E, Obbard ME, Pond B, et al. Experimental test of the efficacy of hunting for controlling human-wildlife conflict. J Wildl Manage. 2022;87(3):e22363. 10.1002/jwmg.22363.

Garshelis DL, Noyce KV, St-Louis V. Population reduction by hunting helps control human-wildlife conflicts for a species that is a conservation success story. PLoS One. 2020;15(8):e0237274. 10.1371/journal.pone.0237274. https://www.ncbi.nlm.nih.gov/pubmed/32780755 .

Obbard ME, Eric J. Howe, Linda L. Wall, Brad Allison, Ron Black, Peter Davis, et al. Relationships among food availability, harvest, and human–bear conflict at landscape scales in Ontario, Canada. Ursus. 2014;25(2):98-110.

See this for side effects of killing black bears
Stillfried M, Belant J, Svoboda N, Beyer D, Kramer-Schadt S. When top predators become prey: Black bears alter movement behaviour in response to hunting pressure. Behav Processes. 2015;120:30-9. 0.1016/j.beproc.2015.08.003.

(c) I offer four recent long-term datasets and reviews of the literature on preventing bear damage to property. The scientific community has not reached consensus on effectiveness of lethal PDM against bears. Again, part of the reason for the lack of consensus is the absence of even one randomized, controlled study of lethal PDM.

d. Robust and reliable study design for inferring the effect of interventions against wildlife damage

Khorozyan I, Waltert M. A framework of most effective practices in protecting human assets from predators. Human Dimensions of Wildlife. 2019;24(4):380-94. 10.1080/10871209.2019.1619883.

Khorozyan I. Dealing with false positive risk as an indicator of misperceived effectiveness of conservation interventions. PLoS One. 2021;16(5):e0255784. https://doi.org/10.1371/journal.pone.0255784 .

Khorozyan I. Defining practical and robust study designs for interventions targeted at terrestrial mammalian predators. Conserv Biol. 2022;36:e13805. 10.1111/cobi.13805.

Treves A, Elbroch L, Koontz F, Papouchis CM. How should scientific review and critique support policy? PLoS One. 2022;Comment on Laundré & Papouchis. https://journals.plos.org/plosone/article/comment?id=10.1371/annotation/5bed4c0f-9676-4b24-a598-ea3bb5bbfd80. https://journals.plos.org/plosone/article/comment?id=10.1371/annotation/5bed4c0f-9676-4b24-a598-ea3bb5bbfd80 .

Although the article below is a pre-print at the time of public comment, I recommend the agency contact atreves@wisc.edu for the published version by the time you read this comment
Treves A, Khorozyan I. Robust inference and errors in studies of wildlife control. Research Square pre-print server for pre-publication review. pre-print. https://doi.org/10.21203/rs.3.rs-3478813/v1. pre-print https://www.researchsquare.com/article/rs-3478813/v1 .

Although this study pertains to non-lethal defenses against elephants, I call attention to it for the analytical design APHIS should use when they have no option to conduct a randomized, controlled trial and are instead forced to conduct retroactive before-and-after analyses of non-randomized samples (also called nBACI).
Rogers A, Treves A, Karamagi R, Nyakoojo M, Naughton-Treves L. Trenches reduce crop foraging by elephants: Lessons from Kibale National Park, Uganda for elephant conservation in densely settled rural landscapes. PLoS One. 2023; 18(7):e0278501. 10.1371/journal.pone.0288115. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0288115.

Christie AP, Amano T, Martin PA, Shackelford GE, Simmons BI, Sutherlan WJ. Simple study designs in ecology produce inaccurate estimates of biodiversity responses. J Appl Ecol. 2019;56:2742–54. 10.1111/1365-2664.13499.

Christie AP, David Abecasis, Mehdi Adjeroud, Alonso JC, Alvaro Anton, Barry P. Baldigo, et al. Quantifying and addressing the prevalence and bias of study designs in the environmental and social sciences. Nature Communications. 2020;11:6377. https://doi.org/10.1038/s41467-020-20142-y

Platt JR. Strong inference. Science. 1964;146:347–53.

Underwood AJ. Beyond baci: The detection of environmental impacts on populations in the real, but variable, world. J Exp Mar Biol Ecol. 1992;161:145-78.

Louchouarn NX, Renn EJ, Anderson G, Parsons DR, Putrevu K, FJ. S-A, et al. Mexican wolf management needs transparency in methods and data to support policy decisions. J Appl Ecol. 2025; in press. https://faculty.nelson.wisc.edu/treves/pubs/Louchouarn_Renn_etal_2025.pdf

Murtaugh PA. On rejection rates of paired intervention analysis. Ecology. 2002;83(6):1752–61. https://doi.org/10.2307/3071993 .

(d) Here I review the advances in scientific processes that make research more reliable.

National Academies of Sciences Engineering & Medicine. Fostering integrity in research. Washington, DC: The National Academies Press; 2017. https://doi.org/10.17226/21896.

Treves A, Paquet PC, Artelle KA, Cornman AM, Krofel M, Darimont CT. Transparency about values and assertions of fact in natural resource management. Frontiers in Conservation Science: Human-Wildlife Dynamics. 2021;2:e631998. 10.3389/fcosc.2021.631998. https://doi.org/10.3389/fcosc.2021.631998

Treves A, Batavia C. Improved disclosures of non-financial competing interests would promote independent review. Academia Letters. 2021;Article 514:1-9. https://www.academia.edu/49267197/Improved_disclosures_of_non_financial_competing_interests_would_promote_independent_review.

Treves A. ‘Authors declare no competing interest’ — really? Front Ecol Environ. 2024;22(5):e2772. :10.1002/fee.2772.

(e) The above papers explain why study designs that do not randomize subjects into treatment group and control group are prone to false discovery errors and other sorts of error due to chance and to bias (unintentional or intentional slanting of estimates away from the real values). I elaborate on randomization, experimental controls, and sources of bias further in Section 2 below.

Goal 2. **I address the need for experimental randomized controls (especially in PDM), three principles of research integrity, and the hierarchy of strength of inference.**

The scientific community has long come to consensus that randomized, controlled study designs are required to infer causality (cause-and-effect mechanisms), e.g., from Platt 1966 to Christie et al. 2020; Khorozyan 2022, Treves & Khorozyan pre-print 2025. The need for randomized, controlled study designs is particularly true for PDM as I explain next.

PDM demands careful experimental controls because any intervention comes with uncertain effects including the possibility of doing the opposite of that desired (protecting property from predator damage). Any actor—private owner of a domestic animal or an agency acting over a broader area and larger time span to attempt prevention of damage or reacting to complaints of damage—may feel convinced they have seen the desired effect, but such anecdotes are not a basis for investing time, effort, and taxpayer resources on potentially counter-productive interventions. Any intervention is a treatment with uncertain effects as I explain in detail below.

It may seem obvious that killing a predator whose jaws are about to clamp down on its prey will save that prey. However, that is not how predator management works anywhere in the world, with the exception of vanishingly rare encounters with predators by some private individuals. Human reactions to predators are almost always not eye-witness affairs. Virtually every time APHIS or any agency intervenes, that action comes later and maybe far from the site of damage. Such remoteness in space and time is especially true for preventive predator damage management which is enacted without even the location of a recent damage incident to orient the manager. Therefore, every intervention in PDM is especially uncertain because it either precedes a known predation event or follows it long after in time and far away in space. That remoteness creates great uncertainty about the effects of PDM.

The remoteness of PDM allows uninvolved individual predators to enter the vicinity, the culprit to leave the vicinity, and errors in identification of the culprit, the predator species or in distinguishing scavenging from predation. Even if the predator species was identified correctly, the wrong individuals are often killed. For example, in Germany, 8 permits were issued to kill individual wolves that were genetically identified from domestic animal kills, but 7 out of the 8 wolves shot for this reason were the wrong individuals (Blanco, J., Sundseth, K. 2023. The situation of the wolf (*Canis lupus*) in the European Union—An in-depth analysis. Publications Office of the European Union, https://urldefense.com/v3/__https://op.europa.eu/en/publication-detail/-/publication/5d017e4e-9efc-11ee-b164-01aa75ed71a1/language-en__;!!Mak6IKo!LBAuIQgtXUaXZkn-htKWfBgPtm2jBry2PhuDjCYWsOutoRCP432OANoUpHSFZzZJbNvP3mzKkT1eYJjxygjk$). Indeed, genomic analyses reveal not uncommon errors in identifying the species of predators attacking domestic animals, especially when wolves and dogs are both present (Plumer, T. N. Talvi, P. Männil, U. Saarma, 2018. Assessing the roles of wolves and dogs in livestock predation and suggestions for mitigating human-wildlife conflict and conservation of wolves. Conserv. Genet. 19, 665–672). Even some predation may not be preventable by killing predators preventively, because a moribund domestic animal may wander into the clutches of a predator who would otherwise have left a healthy domestic animal alone (Allen et al. 2001); APHIS does not require livestock owners to withdraw injured, ill, or otherwise vulnerable animals from predator habitat as far as I know. Therefore, PDM is certain to kill many non-culprits. Is it likely to remove future culprits? The errors introduced by PDM create substantial uncertainty about the cause-and-effect relationship between the intervention and the desired outcome of safer domestic animals.

Abundant research I have cited above examining many carnivore species and the effects of predator removal on both wild ungulates and on domestic animals concur: the effects of removing predators are uncertain.

The scientific remedy for uncertainty about an intervention is to reduce the effects of confounding variables. Confounding variables are those uncontrollable differences between subjects, over time and space, and between researchers and their methods, which can affect the results of intervention or the accuracy of measurements.

Reducing the effects of confounding variables is best done by exerting control over the experimental manipulations and extraneous conditions that could confuse us about the effect of the intervention. That is why the accepted solution to uncertain effects of intervention is to compare treated subjects to “control” subjects. In our context, this could be done by comparing herds or grazing areas—or even individual domestic animals if these are independent one from the other, which is rare—randomly assigned to either PDM treatment or the control (no PDM) condition.

By randomizing assignment of subjects to treatment or control groups, biomedical researchers have managed to exclude the most common confounding variable of sampling or selection bias (many researchers want their experiments to succeed so they intentionally or unintentionally assign the treatment to subjects most likely to show the effect). Random assignment takes the separation of subjects into treatment or control groups out of human hands so ensuring that any pre-existing conditions that might confuse our interpretation of the effect of an intervention are distributed evenly between the treated group and the control group. That is why the gold standard in research is the randomized, controlled trial.

Lethal PDM has not been subject to an unbiased randomized, controlled trial (RCT) in the USA (I return to unbiased below). Such RCTs have been conducted in Australia on red foxes and dingoes to protect sheep and calves from predation; and in the UK to control disease transmission between badgers and cattle. Those RCTs all report the mixed results I have summarized here; namely that killing predators usually has no effect, sometimes has the desired effect and equally commonly has the undesirable, counter-productive effect of raising property losses. In short, the track record for lethal PDM in other countries is poor. It is even poorer in the USA for the following reasons.

When lethal PDM is conducted by a variety of methods (kill traps, explosives, shooting, poison, etc.), each method must be tested by RCT individually. Mixing the methods tends to confuse the effect of any one method. Therefore, an RCT on lethal PDM must also control unregulated killing by private individuals who may wander into the study area. Given the low rate of enforcement of predator protections for species such as grizzly bear and the lack of regulation for killing other predators such as coyote, private individuals may easily subvert experimental studies of agency killing. Also, the agency has been reluctant to frustrate its primary clients, the domestic animal owners, by asking (or compelling) them not to kill wild predators. Regrettably, APHIS has had years to marshal the funding, staffing, and knowledge to conduct an RCT on one of their lethal PDM methods, but has only conducted biased experiments as I explain next.

Besides randomizing subjects into treatment and control groups, RCT require strict safeguards against bias when it comes to administering treatments (or placebo controls) in a uniform, standardized fashion, measuring both groups in identical aways, and analyzing the resulting data without fear or favor for one result or another. In our well-known 2016 study that APHIS tried hard to condemn, we explained in detail why each study by APHIS that purported to be an RCT on lethal PDM was in fact biased in sampling (not randomized or randomization subverted), treatment (inadequate control over the treatment or control conditions), or reporting (incomplete transparency of data or livestock defenses, see Web-panel 1 in Treves A, et al.. Predator control should not be a shot in the dark. Front Ecol Environ. 2016;14:380-8. Yet, we have done more than criticize.

We have completed several RCTs on non-lethal methods (cited above: Ohrens et al. 2019; Louchouarn et al. 2023; and three theses under preparation for peer review). Also, APHIS has conducted apparently unbiased RCTs on non-lethal methods since 2003 at least (e.g., Shivik JA, et al. Non-lethal techniques: Primary and secondary repellents for managing predation. Conserv Biol. 2003;17(6):1531-7. 10.1111/

j.1523-1739.2003.00062.x) and others I cited above (e.g., Young et al. 2019). It is past due to conduct an RCT on their most common lethal PDM method and then every method, or else shelve that method as unproven and potentially counter-productive.

I have alluded to a few of the confounding variables above (was the predator scavenging a domestic animal that died of other causes? Was a different individual or even species actually responsible for the damage? Was the husbandry negligent? Would the culprit predator ever repeat even in the absence of PDM?) These questions are not being answered in the USA as fast as they are being answered in other countries (Treves et al. pre-print 2025 and Grente, et al. Evaluating the effects of wolf culling on livestock predation when considering wolf population dynamics in an individual-based model. Wildl Biol. 2024;2024(6):e01227. 10.1002/wlb3.01227) but the answers are still coming from less robust study designs. By less robust study designs I mean non-randomized, or uncontrolled studies such as non-random before-and-after control-impact (nBACI) designs.

I cited several statisticians above who have explained in great details since 1992 why nBACI designs lead to errors of inference (Underwood 1992; Murtaugh 2002; Christie et al. 2020) and we have shown why this occurs and specifically how it affects removal of predators (Treves & Khorozyan pre-print 2025). This is not the first letter I have written to APHIS trying to persuade them to randomize and use experimental controls. Yet APHIS staff continue to use non-randomized study designs such as nBACI, so I must once again explain why this leads to errors at high rates.

The principle of nBACI is to match a subject (herd, site, individual, etc.) who has received an intervention to one that has not for a paired comparison. Although the desired inference is that any change in the treated subject is due only to the intervention. In practice that never happens. Two subjects are likely to change over time regardless of human intervention. In the context of PDM that means two herds might lose individuals or not, even if humans do nothing to the predators in the area. Because the majority of domestic animal losses are from weather, disease, and accidents, especially in public grazing allotments, herds naturally lose members over time in ways unrelated to predators (and in some grazing situations, gain young from births, which adds a whole new set of non-predator variables that can affect the number of animals in the herd). Therefore, a single pair of herds (one experiencing intervention and another not experiencing intervention) is never adequate to draw a strong inference about the effect of the intervention.

The odds of being right about the effect of a PDM intervention are less than 50% because there are three possible effects of any unknown treatment (make the situation better, do nothing, or make it worse) and both herds can undergo any of those changes. The answer by the scientific community has been to expand nBACI to increase the number of independent subjects monitored so one can measure changes in a large number of treated subjects and a large number of untreated control subjects. If all subjects vary independently of each other over space and time as might different herds in different grazing areas, one can expect the average changes in a herd due to treatment to be detectable as lesser or greater than the average changes in the control herds. That fundamental insight leads to the next insight about randomization.

If we want an unbiased estimate of the effect of our intervention, we need unbiased samples of both treated herds and control herds. The best way to eliminate researcher bias is to randomize the assignment to treatment or control. That means all subjects must be drawn from the same population (all available grazing allotments or all available herds or all available domestic animals). But the demand that subjects be independent of each other argues against using individual domestic animals as your subjects because these are typically aggregated into herds that undergo similar conditions (same grazing areas, same predators, same human husbandry, etc.). Moreover, random assignment must occur before any interventions lest the post hoc selection be biased by clustering of treated subjects and control subjects or some other convenience sampling. In the now infamous APHIS study by Wagner & Conover 1999 discussed below, one of the biases was after the fact assignment (non-random and post hoc) of pastures to the control condition simply because APHIS helicopter pilots were unable to safely reach those pastures. Although it is not easy, the risk of counter-productive effects of PDM going unnoticed makes it imperative that government agencies save time and taxpayer resources by conducting the best, most unbiased RCT possible. I am standing by to help them design and analyze that RCT.

Finally, I wish to remind APHIS of the need for research integrity. RCT may reduce selection bias. This is important but not the only sort of bias to guard against. I summarize these other instances of bias as breaches of research integrity, following the National Academies of Science, Engineering and Medicine 2017 principles for fostering research integrity.

The first breach I have observed in PDM science by APHIS is selective citation. Selective citation is sometimes called cherry-picking, in which the research findings one prefers are promoted and others ignored or dismissed, on bases that do not relate to meticulous consideration of methods. Note I am aware the APHIS staff reading it will retort that I have done that. On the contrary, Web-panel 1 in Treves et al. 2016 meticulously explains each source of bias leading to dismissal of a study, and we dismissed as many studies of non-lethal methods and lethal methods. By contrast, the selective citation I cite in APHIS research is not meticulous.

Symptoms of selective citation include incomplete literature reviews, premature dismissal of studies for inconsistent or capricious reasons, and failure to summarize studies thoroughly to explain any reasoned dismissal on scientific grounds. Most recently, we found selective citation in an article by APHIS staff working on removal of

Mexican wolves from the wild (see the critique of Breck et al. in Louchouarn, Renn, et al. in press 2025). That debate over Mexican wolves relates to our present context because Breck et al. did not acknowledge the copious literature on the negative side-effects of removing wild Mexican wolves by killing them or returning them to captivity. Those side-effects include unregulated killing (poaching) by private domestic animal owners or landowners in the same area. Dismissal of the studies that are inconvenient, and failure to summarize a large body of literature, is breach of research integrity by NAS 2017 standards. Therefore, selective citation leads directly to under-estimating the undesirable side-effects of lethal PDM.

The second breach of scientific integrity associated with APHIS PDM is to leave error-filled scientific research uncorrected or unretracted, leaving error-filled results in print that mislead the public, policy-makers, and future scientific research. The article on aerial gunning of coyotes by Wagner & Conover (1999) is the clearest example of such a breach of research integrity by APHIS. Mitchell et al. (Coyote depredation management: Current methods and research needs. Wildl Soc Bull. 2004;32(4):1209-18) first pointed out the statistical errors and data handling mistakes in Wagner & Conover 1999, then we added to this critique in 2016 (Treves, et al.. 2016 Web-panel 1), when we exposed sampling bias, treatment bias, and reporting bias in Wagner & Conover 1999. We then wrote the editor, publisher, and authors to seek retraction of that APHIS study. However, the response of Wagner was to defend their study using new information that was incompatible with the original published paper and to do so in a sworn affidavit in federal court (Western Watersheds Project et al. v APHIS, U.S. District Court Idaho 1:17-cv-00206-BLW Doc 22-3, 2018). Incompatible claims about research methods make a study irreproducible. Reproducibility is a hallmark of scientific research. Therefore, a PDM study like Wagner & Conover 1999 should be retracted and never be cited affirmatively by any government body. Moreover, claims that aerial gunning of coyotes is an effective PDM should not be made.

Third, through transparent disclosures of competing interests are an essential component of research integrity (NAS 2017). To avoid the appearance of concealing bias, all authors of scientific work should expose their investments and interests to scrutiny by thorough disclosures of potentially competing interests, whether financial or non-financial. Such failures spawn distrust in science and in the authors and the agencies with which they are affiliated. This can be remedied simply by a single policy for the entire agency requiring authors of scientific work to disclose all of the following lose their privilege of publishing: does their career, promotion, job security, or salary depend on certain policies related to the published work? Or do they receive compensation or honoraria for any activities outside their federal post? And non-financial: do they belong to organizations, professional societies, for which they speak, write, advise, or hold a leadership position? None the APHIS author I have cited above mention that the agency is beholden to financial agricultural interests and political pressures for their job security and advancement. That makes APHIS a dubious source of scientific findings, just as any industry researcher is dubious, especially when undisclosed. Again, the recommendations of the scientific community are to make all such competing interests transparent and clear so readers can judge for themselves. Until APHIS staff authors come clean, the public and the international scientific community has little reason to believe their findings.

1.

2. **Goal 3. Killing predators reduces the benefits of coexistence between predators and people**

3.

Ideal public policy maximizes the benefits (minus associated costs of) management interventions. To balance the more common discourse about the risks predators pose (i.e., to human safety, livestock, and wild ungulates), we find it appropriate to detail potential benefits to humans associated with coexisting with, rather than killing, predators. In general, research shows that most audiences appreciate carnivores, e.g., cougars (*Puma concolor*) and coyotes (*Canis latrans*); Bruskotter et al. 2018; Manfredo et al. 2020), and that people report both financial and non-financial benefits of wildlife (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 and revenues that far exceeded the costs of reintroduction (Duffield and Neher 1996; Duffield et al. 2008). In addition, grizzly bears are one of the top species for ecotourism in North America (Penteriani et al. 2017). In Yellowstone National Park, summer visitation would likely decline if bears were excluded from roadside habitats (Richardson et al. 2014), and in British Columbia, bear-viewing revenue has surpassed bear-hunting revenue by an order of magnitude (Honey et al. 2016). The benefits of carnivores also extend to human safety: findings from Wisconsin 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). The longer wolves lived in those counties the lower the rate of deer-vehicle collisions, emphasizing the importance of leaving wolf packs undisturbed for years.

The studies of benefits of predators have often grown out of an awareness that apex predators such as wolves were changing the behavior of deer and elk and some evidence of carnivores' broader ecosystem effects. Many studies suggest grizzly bears and grey wolves can benefit ecosystems through their effects on prey and ecological communities. For example, their combined presence has been associated with higher species richness and nesting density of birds (Berger et al. 2001). Grizzlies can serve as important seed dispersers of numerous plants (Willson and Gende 2004), play a role in nutrient cycles (Hilderbrand et al. 1999), shape food web structure (Levi et al. 2020), and provide nutrition to small mammals through their seed-rich scat (Shakeri et al. 2018). Wolves may reduce the incidence or transmission of zoonotic and wildlife diseases (Wild et al. 2011; Tanner et al. 2019), increase scavenger diversity (reviewed in Smith et al. 2003), and reduce deer damage to vegetation (reviewed in Martin et al. 2020). Regarding the latter, rare understory plants fared better near the center of grey wolf pack territories in Wisconsin (Callan et al. 2013). Also, forests were more biodiverse, more mature, had higher tree volumes and regeneration rates, and resisted non-native plant invasions in the presence of wolves (Waller and Reo 2018). Though such effects may vary with conditions, research suggests wolves and bears enhance biodiversity via direct and indirect pathways that begin with limiting ungulate herbivory (Estes et al. 2011), or by altering the competition between prey species.

The persistent debate about Yellowstone's wolves notwithstanding, scientific consensus holds that top predators generally play crucial roles in ecosystem diversity, resilience, and health (Estes et al. 2011; LaBarge et al. 2022). Killing predators is not cost-free, and so we need to weigh the use of public funds for killing against the benefits minus the costs of maintaining predator populations or expanding their ranges. It is not at all clear that aggressive killing of carnivores will significantly reduce the real or perceived risks associated with living with these species. Conversely, it is likely that the large-scale killing of predators will substantially diminish the benefits associated with their presence. We highlight the need for formal comparisons between the benefits associated with apex carnivores and the economic costs long attributed to them (Gilbert et al. 2021), to set policies that optimize carnivores' beneficial contributions to ecosystems and human communities.

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