Managing Conflict: *Coexistence with Bears, Cougars, and Wolves*

A literature reference

Introduction

Wolves, bears, and mountain lions are symbolic and contested animals. They are native species and vital to ecosystem health. They represent wilderness and mystery to many, but to others they represent encumbrance and destruction. Whether large carnivore populations expand numerically or spatially is not a question just for the natural sciences. The issue is ultimately grounded in human values and perspectives about the natural world. Large carnivore restoration and persistence is directly tied to our willingness and commitment to living with and alongside them.

Promoting or practicing coexistence and human-wildlife conflict prevention requires navigating a complex and, at times, contentious management landscape. To assist practitioners, advocates, and managers in this work, we have written and compiled summaries of peer-reviewed research papers across a variety of disciplines relative to large carnivore conservation and conflict management, since 2000. The collection is broad but we have not included papers on backcountry encounters, bear spray, or direct conflicts with people; specific field research applications are primarily agricultural. Due to volume, we limited the collection primarily to North American research.

Below are descriptions of the categories included in the compilation.

Collaborative and Community-Based Practice and Management: This category reflects experiences and best practices for engaging local citizens and communities or for using collaborative strategies.

Compensation Programs: These papers are about different kinds of livestock loss compensation programs or other schemes to prevent conflicts or conserve carnivore habitat.

Habitat Conditions, Movement, and Connectivity: This grouping reflects information about the habitat attributes that can cause or predict conflict, or conditions needed for connectivity or dispersal.

Hunting: This category relates to how hunting may relate to or possibly cause conditions leading to large carnivore conflicts. This does not include studies about the use of hunting as a tool for predator control.

Patterns of Conflict: This section includes studies about the causes or risks of conflict as well as conflict over time and across multiple/different scales.

Policy, Governance and Social Science: This is an umbrella category under which are two sub-groupings: Policy & Governance, and Social Science. The former is self-explanatory; the latter relates to values and attitudinal research, and papers asserting the relevance of social science to management decisions.

Lethal Control: This includes papers about the effectiveness or impacts of lethal control strategies.

Nonlethal and Preventative Tools: This grouping reflects studies of the efficiency and effectiveness of various nonlethal conflict prevention or mitigation tools and practices.

The compilation index begins on the next page. In many cases papers are in more than one category. Citations are abbreviated in the index but are provided in full with the abstract summaries (beginning on page 26). We recognize that there are many informative materials in circulation relating to this topic; here, we abstracted peer-reviewed journal articles only, published within the last 20 years.

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Browne-Nunez C, Treves A, MacFarland D, Voyles Z, Turnig C. 2015. Tolerance of Wolves in Wisconsin: A Mixed Methods Examination of Policy Effects on Attitudes and Behavioral Inclinations. *Biological Conservation* [p41]

Carter NH, Linnell JDC. 2016. Co-Adaptation is Key to Coexisting with Large Carnivores. *Trends in Ecology and Evolution* [p45]

Chamberlain E, Rutherford M, Gibeau M. 2012. Human Perspectives and Conservation of Grizzly Bears in Banff National Park, Canada. *Conservation Biology* [p45]

Clark DA, Slocombe DS. 2011. Adaptive Co-Management and Grizzly Bear-Human Conflicts in Two Northern Canadian Aboriginal Communities. *Human Ecology* [p46]

Clark DA, Slocombe DS. 2011. Grizzly Bear Conservation in the Foothills Model Forest: Appraisal of a Collaborative Ecosystem Management Effort. *Policy Sciences* [p47]

Coleman TH, Schwartz CC, Gunther KA, Creel S. 2013. Grizzly Bear and Human Interaction in Yellowstone National Park: An Evaluation of Bear Management Areas. *Journal of Wildlife Management* [p47]

Coogan SCP, Coops NC, Janz DM, Cattet MRL, Kearney SP, Stenhouse GB, Nielsen SE. 2019. Towards Grizzly Bear Population Recovery in a Modern Landscape. *Journal of Applied Ecology* [p48]

Lopez-Bao J, Chapron G, Treves A. 2017. The Achilles Heel of Participatory Conservation. *Biological Conservation* [p79]

Madden F. 2007. Creating Coexistence Between Humans and Wildlife: Global Perspectives on Local Efforts to Address Human-Wildlife Conflict. *Human Dimensions of Wildlife* [p82]

Madden F, McQuinn, B. 2014. Conservation's Blind Spot: The Case for Conflict Transformation in Wildlife Conservation. *Biological Conservation* [p83]

Mattson DJ, Byrd KL, Rutherford MB, Brown SR, Clark TW. 2006. Finding Common Ground in Large Carnivore Conservation: Mapping Contending Perspectives. *Environmental Science and Policy* [p84]

Muhly TB, Dubois M. 2013. Advancing the Management of Carnivore Predation on Livestock in Western Canada. *Human Dimensions of Wildlife* [p91]

Primm SA, Wilson SM. 2004. Reconnecting Grizzly Bear Populations: Prospects for Participatory Projects. *Ursus* [p103]

Redpath SM, Linnell JDC, Festa-Bianchet M, Boitani L, Bunnefeld N, Dickman A, Gutierrez RJ, Irvine JR, Johansson M, Majic A, McMahon BJ, Pooley S, Sandstrom C, Sjolander-Lindqvist A, Skogen K, Swenson JE, Trouwborst A, Young J, Milner-Gulland EJ. 2017. Don't Forget to Look Down—Collaborative Approaches to Predator Conservation. *Biological Reviews* [p106]

Richie L, Oppenheimer JD, Clark SG. 2012. Social Process in Grizzly Bear Management: Lessons for Collaborative Governance and Natural Resource Policy. *Policy Sciences* [p107]

Rutherford MB, Gibeau ML, Clark SG, Chamberlain EC. 2009. Interdisciplinary Problem Solving Workshops for Grizzly Bear Conservation in Banff National Park, Canada. *Policy Sciences* [p110]

Treves A, Wallace RB, White S. 2009. Participatory Planning of Interventions to Mitigate Human-Wildlife Conflicts. *Conservation* Biology [p129]

Wilson S, Bradley E, Neudecker G. 2017. Learning to Live with Wolves: Community Based Conservation in the Blackfoot Valley of Montana. *Human-Wildlife Interactions* [p136]

Compensation Programs

Agarwala M, Kumar S, Treves A, Naughton-Treves L. 2010. Paying for Wolves in Solapur, India, and Wisconsin, USA: Comparing Compensation Rules and Practices to Understand the Goals and Politics of Wolf Conservation. *Biological Conservation* [p26]

Bautista C, Naves J, Revilla E, Fernandez N, Albrecht J, Scharf AK, Rigg R, Karamanlidis AA, Jerina K, Huber D, Palazon S, Kont R, Ciucci P, Groff C, Dutsov A, Seijas J, Quenette P-I, Olszanska A, Shkvyria M, Adamec M, Ozolins J, Jonozovic M, Selva N. 2017. Patterns and Correlates of Claims for Brown Bear Damage on a Continental Scale. *Journal of Applied Ecology* {p31}

Breck SW, Kluever BM, Panasci M, Oakleaf J, Johnson T, Howery L, Bergman DL. 2011. Domestic Calf Mortality and Producer Detection Rates in the Mexican Wolf Recovery Area: Implications for Livestock Management and Carnivore Compensation Schemes*. Biological Conservation* [p40]

Dickman AJ, Macdonald EA, Macdonald DW. 2011. A Review of Financial Instruments to Pay for Predator Conservation and Encourage Human-Carnivore Coexistence. *Proc Natl Acad Sci* [p51]

Gunther KA, Haroldson MA, Frey K, Cain SL, Copeland J, Schwartz C. 2004. Grizzly Bear-Human Conflicts in the Greater Yellowstone Ecosystem, 1992-2000. *Ursus* [p60]

Jacobs CE, Main MB. 2015. A Conservation-Based Approach to Compensation for Livestock Depredation: The Florida Panther Case Study. *PLoS ONE* [p66]

Laporte I, Muhly TB, Pitt JA, Alexander M, Musiani M. 2010. Effects of Wolves on Elk and Cattle Behaviors: Implications for Livestock Production and Wolf Conservation. *PLoS ONE* [p76]

Larson S, McGranahan DA, Timm RM. 2019. The Marin County Livestock Protection Program: 15 Years in Review. *Human-Wildlife Interactions* [p77]

Lee T, Good K, Jamieson W, Quinn M, Krishnamurthy A. 2016. Cattle and Carnivore Coexistence in Alberta: The Role of Compensation Programs. *Rangelands* [p77]

Morehouse AT, Tigner J, Boyce MS. 2018. Coexistence with Large Carnivores Supported by a Predator-Compensation Program. *Environmental Management* [p89]

Muhly TB, Dubois M. 2013. Advancing the Management of Carnivore Predation on Livestock in Western Canada. *Human Dimensions of Wildlife* [p91]

Muhly, TB., Musiani, M. 2009. Livestock Depredation by Wolves and the Ranching Economy in the Northwestern U.S. *Ecological Economics* [p91]

Naughton-Treves L, Grossberg R, Treves A. 2003. Paying for tolerance: Rural Citizens' Attitudes Toward Wolf Depredation and Compensation. *Conservation Biology* [p94]

Ramler JP, Hebblewhite M, Kellenberg K, Sime C. 2014. Crying Wolf? A Spatial Analysis of Wolf Location and Depredations on Calf Weight. *American Journal of Agricultural Economics* [p104]

Ravenelle J, Nyhus PJ. 2017. Global Patterns and Trends in Human-Wildlife Conflict Compensation. *Conservation Biology* [p105]

Sommers AP, Price CC, Urbigkit CD, Peterson EM. 2010. Quantifying Economic Impacts of Large-Carnivore Depredation on Bovine Calves. *Journal of Wildlife Management* [p120]

Steele JR, Rashford BS, Foulke TK, Tanaka JA, Taylor DT. 2013. Wolf (Canis lupus) Predation Impacts on Livestock Production: Direct Effects, Indirect Effects, and Implications for Compensation Ratios. *Rangeland Ecol Manage* [p121]

Treves A, Jurewicz RL, Naughton-Treves L, Wilcove DS. 2009. The Price of Tolerance: Wolf Damage Payments after Recovery. *Biodivers Conserv* [p126]

Habitat Conditions, Movement, and Connectivity

Adams, M, Service C, Bateman A, Bourbonnais M, Artelle K, Nelson T, Paquet P, Levi T, Darimont C. 2017. Intrapopulation Diversity in Isotopic Niche over Landscapes: Spatial Patterns Inform Conservation of Bear–Salmon systems. *Ecosphere* [p26]

Allen J, Venter O, Watson M. 2017. Temporarily Inter-Comparable Maps of Terrestrial Wilderness and the Last of the Wild. *Scientific Data* [p27]

Amirkhiz RG, Frey JK, Cain JW, Breck SW, Bergman DL. 2018. Predicting Spatial Factors Associated with Cattle Depredations by the Mexican Wolf (*Canis lupus baileyi*) with Recommendations for Depredation Risk Modeling. *Biological Conservation* [p28]

Apps CD, McLellan BN, Proctor MF, Stenhouse GB, Servheen C. 2016. Predicting Spatial Variation in Grizzly Bear Abundance to Inform Conservation. *Journal of Wildlife Management* [p29]

Artelle KA, Anderson SC, Reynolds JD, Cooper AB, Paquet PC, Darimont CT. 2016. Ecology of Conflict: Marine Food Supply Affects Human-Wildlife Interactions on Land. *Scientific Reports* [p29]

Baruch-Mordo S, Wilson K, Lewis D, Broderick J, Mao J, et al. 2014. Stochasticity in Natural Forage Production Affects Use of Urban Areas by Black Bears: Implications to Management of Human-Bear Conflicts**.** *PLoS ONE* [p30]

Benson JF, Mahoney PJ, Vickers TW, Sikich JA, Beier P, Riley SPD, Ernest HB, Boyce WM. 2019. Extinction Vortex Dynamics of Top Predators Isolated by Urbanization. *Ecological Applications* [p32]

Bontrager A, Kretser H, Leong K, Conelly N. 2016. Conservation Opportunity and Risk Mapping for Carnivores Using Landowner Survey Data from the Greater Yellowstone Ecosystem**.** *The Professional Geographer* [p37]

Carroll C, Parks S, Dobrowski S, Roberts D. 2018. Climatic, Topographic, and Anthropogenic Factors Determine Connectivity Between Current and Future Climate Analogs in North America. *Global Change Biology* [p43]

Carroll C, Rohlf DJ, Li Y-W, Phillips MK, Noss RF. 2014. Connectivity Conservation and Endangered Species Recovery: A Study in the Challenges of Defining Conservation-Reliant Species. *Conservation Letters* [p44]

Coleman TH, Schwartz CC, Gunther KA, Creel S. 2013. Grizzly Bear and Human Interaction in Yellowstone National Park: An Evaluation of Bear Management Areas. *Journal of Wildlife Management* [p47]

Costello CM, van Manen FT, Haroldson MA, Ebinger MR, Cain SL, Gunther KA, Bjornlie DD. 2014. Influence of Whitebark Pine Decline on Fall Habitat Use and Movements of Grizzly Bears in the Greater Yellowstone Ecosystem. *Ecology and Evolution* [p48]

Dilkina B, Houtman R, Gomes CP, Montgomery CA, McKelvey KS, Kendall K, Graves TA, Bernstein R, Schwartz MK. 2016. Trade-offs and Efficiencies in Optimal Budget-Constrained Multispecies Corridor Networks. *Conservation Biology* [p52]

Elfstrom M, Zedrosser A, Stoen O-G, Swenson JE. 2014. Ultimate and Proximate Mechanisms Underlying the Occurrence of Bears Close to Human Settlements: Review and Management Implications. *Mammal Review* [p54]

Evans MJ, Hawley JH, Rego PW, Rittenhouse TAG. 2014. Exurban Land Use Facilitates Human-Black Bear Conflicts. *Journal of Wildlife Management* [p55]

Evans MJ, Rittenhouse TAG, Hawley JE, Rego PW, Eggert LS. 2018. Spatial Genetic Patterns Indicate Mechanism and Consequences of Large Carnivore Cohabitation within Development. *Ecology and Evolution* [p55]

Finnegan L, Pigeon K, Cranston J, Hebblewhite M, Musiani M, Neufeld L, Schmiegelow F, Duval J, Stenhouse GB. 2018. Natural Regeneration on Seismic Lines Influences Movement Behavior of Wolves and Grizzly Bears. *PLoS ONE* [p56]

Fowler NL, Belant JL, Beyer DE. 2019. Non-Linear Relationships Between Human Activities and Wolf-Livestock Depredations. *Biological Conservation* [p56]

Fremier AK, Kiparsky M, Gmur S, Aycrigg J, Craig RK, Svancara LK, Goble DD, Cosens B, Davis FW, Scott JM. 2015. A Riparian Conservation Network for Ecological Resilience. *Biological Conservation* [p57]

Graves R, Williamson M, Belote T, Brandt J. 2019. Quantifying the Contribution of Conservation Easements to Large-Landscape Conservation. *Biological Conservation* [p59]

Grilo C, Lucas PM, Fernández-Gil A, Seara M, Costa G, Roque S, Rio-Maior H, Nakamura M, Álvares F, Petrucci-Fonseca F, Revilla E. 2018. Refuge as a Major Habitat Driver for Wolf Presence in Human-Modified Landscapes. *Animal Conservation* [p60]

Gunther KA, Shoemaker RR, Frey KL, Haroldson MA, Cain SL, van Manen FT, Fortin JK. 2014. Dietary Breadth of Grizzly Bears in the Greater Yellowstone Ecosystem. *Ursus* [p61]

Gunther KA, Wilmot KR, Cain SL, Wyman T, Reinertson EG, Bramblett AM. 2018. Managing Human-Habituated Bears to Enhance Survival, Habitat Effectiveness and Public Viewing. *Human-Wildlife Interactions* [p61]

Haswell PM, Shepherd EA, Stone SA, Purcell B, Hayward MW. 2019. Foraging Theory Provides a Useful Framework for Livestock Predation Management. *J Nat Conserv* [p63]

Jacobs CE, Main MB. 2015. A Conservation-Based Approach to Compensation for Livestock Depredation: The Florida Panther Case Study. *PLoS ONE* [p66]

Jakes A, Jones P, Paige C, Seidler R, Huijser M. 2018. A Fence Runs Through it: A Call for Greater Attention to the Influence of Fences on Wildlife and Ecosystems. *Biological Conservation* [p66]

Kendall KC, Stetz JB, Boulanger J, Macleod AC, Paetkau D, White GC. 2009. Demography and genetic structure of a recovering grizzly bear population. *J Wildlife Management* [p68]

Kertson BN, Spencer RD, Marzluff JM, Hepinstall-Cymerman J, Grue CE. 2011. Cougar Space Use and Movements in the Wildland-Urban Landscape of Western Washington. *Ecological Applications* [p69]

Lacher I, Wilkerson ML. 2013. Wildlife Connectivity Approaches and Best Practices in U.S. State Wildlife Action Plans. *Conservation Biology* [p72]

Ladle A, Steenweg R, Shepard B, Boyce M. 2018. The Role of Human Outdoor Recreation in Shaping Patterns of Grizzly Bear-Black Bear Co-occurrence. *PLoS ONE* [p73]

Lamb C, Mowat G, Reid A, et al. 2018. Effects of Habitat Quality and Access Management on the Density of a Recovering Grizzly Bear Population. *J Appl Ecol* [p73]

Lamb CT, Mowat G, McLellan BN, Nielsen SC, Boutin S. Forbidden Fruit: Human Settlement and Abundant Fruit Create an Ecological Trap for an Apex Omnivore. *J Anim Ecol* [p74]

Lambert CMS, Wielgus RB, Robinson HS, Katnik DD, Cruickshank HS, Clark R, Almack J. 2006. Cougar population dynamics and viability in the Pacific Northwest. *Journal of Wildlife Management* [p74]

Lopez Bao J, Bruskotter J. 2017. Finding Space for Large Carnivores. *Nature Ecology and Evolution* [p79]

Maletzke B, Kertson B, Swanson M, Koehler G, Beausoleil R, Wielgus R, Cooley H. 2017. Cougar Response to a Gradient of Human Development. *Ecosphere* [p83]

Miller JRB. 2015. Mapping Attack Hotspots to Mitigate Human-Carnivore Conflict: Approaches and Applications of Spatial Predation Risk Modeling. *Biodivers Conserv* [p86]

Milligan S, Brown L, Hobson D, Frame P, Stenhouse G. 2018. Factors Affecting the Success of Grizzly Bear Translocations. *Journal of Wildlife Management* [p87]

Morehouse AT, Boyce MS. 2011. From Venison to Beef: Seasonal Changes in Wolf Diet Composition in a Livestock Grazing Landscape. *Frontiers in Ecology and the Environment* [p87]

Morehouse AT, Graves TA, Mickle N, Boyce MS. 2016. Nature vs. Nurture: Evidence for Social Learning of Conflict Behavior in Grizzly Bears. *PLoS ONE* [p88]

Moss WE, Alldredge MW, Pauli JN. 2016. Quantifying Risk and Resource Use for a Large Carnivore in and Expanding Urban-Wildlife Interface. *J Appl Ecol* [p90]

Murray MH, Fassina S, Hopkins JB, Whittington J, St. Clair CC. 2017. Seasonal and Individual Variation in the Use of Rail-Associated Food Attractants by Grizzly Bears (*Ursus arctos*) in a National Park. *PLoS ONE* [p92]

Nelson AA, Kauffman MJ, Middleton AD, Jimenez MD, McWhirter DE, Barber J, Gerow K. 2012. Elk Migration Patterns and Human Activity Influence Wolf Habitat Use in the Greater Yellowstone Ecosystem. *Ecological Applications* [p94]

Nelson AA, Kauffman MJ, Middleton AD, Jimenez MD, McWhirter DE, Gerow K. 2016. Native Prey Distribution and Migration Mediates Wolf (*Canis lupus*) Predation on Domestic Livestock in Greater Yellowstone Ecosystem. *Canadian Journal of Zoology* [p95]

Northrup J, Stenhouse G, Boyce M. 2012. Agricultural Lands as Ecological Traps for Grizzly Bears. *Animal Conservation* [p98]

Obbard ME, Howe EJ, Wall LL, Allison B, Black R, Davis P, Dix-Gibson L, Gatt M, Hall MN. 2014. Relationships Among Food Availability, Harvest, and Human-Bear Conflict at Landscape Scales in Ontario, Canada. *Ursus* [p99]

Olson ER, Van Deelen TR, Wydeven AP, Ruid DB, MacFarland DM, Ventura SJ. 2019. A Landscape of Overlapping Risks for Wolf-Human Conflict in Wisconsin, USA. *Journal of Environmental Management* [p100]

Peck C, van Manen F, Costello C, Haroldson M, Landenburger L, Roberts L, Bjornlie D, Mace R. 2017. Potential Paths for Male-Mediated Geneflow to and from an Isolated Grizzly Bear Population. *Ecosphere* [p102]

Proctor M, Kasworm W, Annis K, MacHutchon A, Teisberg J, Radandt T, Servheen C. 2018. Conservation of Threatened Canada-USA Trans-border Grizzly Bears Linked to Comprehensive Conflict Reduction. *Human–Wildlife Interactions* [p103]

Proctor MF, Nielsen SE, Kasworm WF, Servheen C, Radandt TG, Machutchon AG, Boyce MS. 2015. Grizzly Bear Connectivity Mapping in the Canada-United States Trans-Border Region. *Journal of Wildlife Management* [p104]

Robins CW, Kertson BN, Faulkner J, Wirsing AJ. 2019. Effects of Urbanization on Cougar Foraging Ecology Along the Wildland-Urban Gradient of Western Washington. *Ecosphere* [p107]

Roever C, Boyce M, Stenhouse G. 2010. Grizzly Bear Movements Relative to Roads: Application of Step Selection Functions. *Ecograph* [p108]

Rush T, Haroldson M, Murphy K, Boutte P, Hornocker M, Quigley H. 2011. Cougar Survival and Source-Sink Structure on Greater Yellowstone's Northern Range. *Journal of Wildlife Management* [p109]

Rutledge LY, Patterson BR, Mills KI, Loveless KM, Murray DL, White BN. 2010. Protection from harvesting restores the natural social structure of eastern wolf packs. *Biological Conservation* [p111]

Sawaya MA, Clevenger AP, Kalinowski ST. 2013. Demographic Connectivity for Ursid Populations at Wildlife Crossing Structures in Banff National Park. *Conservation Biology* [p112]

Sazatornil V, Rodgriquez A, Klaczek M, Ahmadi M, Alvares F, Arthur S, Blanco JC, Borg BL, Cluff D, Cortes Y, Garcia EJ, Geffen E, Habib B, Iliopoulos Y, Kaboli M, Krofel M, Llaneza L, Marucco F, Oakleaf JK, Person DK, Potocnik H, Razen N, Rio-Maior H, Sand H, Unger D, Wabakken P, Lopez-Bao JV. 2016. The Role of Human-Related Risk in Breeding Site Selection by Wolves. *Biological Conservation* [p112]

Schwartz CC, Haroldson MA, White GC. 2010. Hazards Affecting Grizzly Bear Survival in the Greater Yellowstone Ecosystem. *Journal of Wildlife Management* [p114]

Schwartz C, Haroldson M, White G, Harris R, Cherry S, Keating K, Moody D, Servheen C. 2006. Temporal, Spatial, and Environmental Influences on the Demographics of Grizzly Bears in the Greater Yellowstone Ecosystem. *Wildlife Monographs* [p115]

Smith DW, Bangs EE, Oakleaf JK, Mack C, Fontaine J, Boyd D, Jimenez M, Pletscher DH, Niemeyer CC, Meier TJ, Stahler DR, Holyan J, Asher VJ, Murray DL. 2010. Survival of Colonizing Wolves in the Northern Rocky Mountains of the United States, 1982-2004. *Journal of Wildlife Management* [p118]

Snijders L, Greggor AL, Hilderink F, Doran C. 2019. Effectiveness of Animal Conditioning Interventions in Reducing Human–Wildlife Conflict: a Systematic Map Protocol. *Environ Evid* [p120]

Stewart BP, Nelson TA, Laberee K, Nielsen SE, Wulder MA, Stenhouse G. 2013. Quantifying Grizzly Bear Selection with Natural and Anthropogenic Edges. *Journal of Wildlife Management* [p122]

Suzuki N, Parker KL. 2016. Potential Conflict Between Future Development of Natural Resources and High-Value Wildlife Habitats in Boreal Landscapes. *Biodivers Conserv* [p123]

Sweanor LL, Logan KA, Hornocker MG. 2000. Cougar Dispersal Patterns, Metapopulation Dynamics, and Conservation. *Conservation Biology* [p124]

Vijayan S, Morris DW, McLaren BE, Mukherjee S. 2017. Domestic Ungulates in Protected Areas and the Potential for Indirect Interactions Via Shared Predation. *Biodiversity* [p132]

VonHoldt BM, Stahler DR, Bangs EE, Smith DW, Jimenez MD, Mack CM, Niemeyer CC, Pollinger JP, Wayne RK. 2010. A Novel Assessment of Population Structure and Gene Flow in Grey Wolf Populations of the Northern Rocky Mountains of the United States. *Molecular Ecology* [p133]

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Burchfield JA, Belsky JM. 2005. Natural Landscape Features, Human-Related Attractants, and Conflict Hotspots: A Spatial Analysis of Human-Grizzly Bear Conflicts. *Ursus* [p137]

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Merrill T. 2006. Landscape Conditions Predisposing Grizzly Bears to Conflicts on Private Agricultural Lands in the Western USA. *Biological Conservation* [p137]

Wolf C, Ripple W. 2018. Rewilding the World's Large Carnivores. *R. Soc. Open Sci* [p138]

Zarco-Gonzalez, M., Monroy-Vilchis, O., Rodriguez-Soto, C., Urios, V. 2012. Spatial Factors and Management Associated with Livestock Predations by *Puma concolor* in Central Mexico. *Human Ecology* [p141]

Zeller KA, Wattles DW, Conlee L, DeStefano S. 2019. Black Bears Alter Movements in Response to Anthropogenic Features with Time of Day and Season. *Movement Ecology* [p142]

Hunting

Hiller TL, McFadden-Hiller JE, Jenkins SR, Belant JL, Tyre AJ. 2015. Demography, Prey Abundance, and Management Affect Number of Cougar Mortalities Associated with Livestock Conflict. *Journal of Wildlife Management* [p64]

Hogberg J, Treves A, Shaw B, Naughton-Treves L. 2014. Changes in Attitudes Toward Wolves Before and After an Inaugural Public Hunting and Trapping Season: Early Evidence from Wisconsin's Wolf Range. *Environmental Conservation* [p64]

Lambert CMS, Wielgus RB, Robinson HS, Katnik DD, Cruickshank HS, Clark R, Almack J. 2006. Cougar population dynamics and viability in the Pacific Northwest. *Journal of Wildlife Management* [p74]

Ordiz A, Bischof R, Swenson JE. 2013. Saving Large Carnivores, but Losing the Apex Predator? *Biological Conservation* [p101]

Peebles KA, Wielgus RB, Maletzke BT, Swanson ME. 2013. Effects of Remedial Sport Hunting on Cougar Complaints and Livestock Depredation. *PLoS ONE* [p102]

Robinson HS, Wielgus RB, Cooley HS, Cooley SW. 2008. Sink Populations in Carnivore Management: Cougar Demography and Immigration in a Hunted Population. *Ecological Applications* [p108]

Rutledge LY, Patterson BR, Mills KI, Loveless KM, Murray DL, White BN. 2010. Protection from harvesting restores the natural social structure of eastern wolf packs. *Biological Conservation* [p111]

Teichman KJ, Cristescu B, Darimont CT. 2016. Hunting as a Management Tool? Cougar-Human Conflict is Positively Related to Trophy Hunting. *BMC Ecology* [p124]

Treves A, Artelle K, Paquet P. 2018. Differentiating Between Regulation and Hunting as Conservation Interventions. *Conservation Biology* [p125]

Treves A, Martin KA. 2011. Hunters as Stewards of Wolves in Wisconsin and the Northern Rocky Mountains, USA. *Society and Natural Resources* [p126]

Way J, Bruskotter J. 2012. Additional Considerations for gray wolf management after their removal from endangered species act protections. *Journal of Wildlife Management* [p135]

Patterns of Conflict

Amirkhiz RG, Frey JK, Cain JW, Breck SW, Bergman DL. 2018. Predicting Spatial Factors Associated with Cattle Depredations by the Mexican Wolf (*Canis lupus baileyi*) with Recommendations for Depredation Risk Modeling. *Biological Conservation* [p28]

Artelle KA, Anderson SC, Reynolds JD, Cooper AB, Paquet PC, Darimont CT. 2016. Ecology of Conflict: Marine Food Supply Affects Human-Wildlife Interactions on Land. *Scientific Reports* [p29]

Baruch-Mordo S, Wilson K, Lewis D, Broderick J, Mao J, Breck S. 2014. Stochasticity in Natural Forage Production Affects Use of Urban Areas by Black Bears: Implications to Management of Human-Bear Conflicts. *PLoS ONE* [p30]

Bautista C, Naves J, Revilla E, Fernandez N, Albrecht J, Scharf AK, Rigg R, Karamanlidis AA, Jerina K, Huber D, Palazon S, Kont R, Ciucci P, Groff C, Dutsov A, Seijas J, Quenette P, Olszanska A, Shkvyria M, Adamec M, Ozolins J, Jonozovic M, Selva N. 2017. Patterns and Correlates of Claims for Brown Bear Damage on a Continental Scale. *J Appl Ecol* [p31]

Benson JF, Sikich JA, Riley SPD. 2019. Survival and competing mortality risks of mountain lions in a major metropolitan area. *Biological Conservation* [p32]

Blecha K, Boone R, Aldridge M. 2018. Hunger Mediates Apex Predator's Risk Avoidance Response in Wildland–Urban Interface. *J Anim Ecol* [p35]

Boast L, Houser AM, Horgan J, Reeves H, Phale P, Klein R. 2016. Prey Preferences of Free-Ranging Cheetahs on Farmland: Scan Analysis Versus Farmer Perceptions. *African Journal of Ecology* [p35]

Bombieri G, Delgado M, Russo LF, Garrote PJ, López-Bao JV, Fedriani JM, Penteriani V. 2018. Patterns of Wild Carnivore Attacks on Humans in Urban Areas. *Scientific Reports* [p36]

Bombieri G, Naves J, Penteriani V, Selva N, Fernández-Gil A, López-Bao JV, Ambarli H, Bautista C, Bespalova T, Bobrov V, Bolshakov V, Bondarchuk S, Camarra JJ, Chiriac S, Ciucci P, Dutsov A, Dykyy I, Fedriani JM. 2019. Brown Bear Attacks on Humans: A Worldwide Perspective. *Scientific Reports* [p37]

Bontrager A, Kretser H, Leong K, Connelly N. 2017. Conservation Opportunity and Risk Mapping for Carnivores Using Landowner Survey Data from the Greater Yellowstone Ecosystem. *Professional Geographer* [p37]

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* [p38]

Breck SW, Clark P, Howery L, Johnson D, Kluever BM, Smallidge S, Cibils AF. 2012. A Perspective on Livestock-Wolf Interactions on Western Rangelands. *Rangelands* [p39]

Breck SW, Kluever BM, Panasci M, Oakleaf J, Johnson T, Howery L, Bergman DL. 2011. Domestic Calf Mortality and Producer Detection Rates in the Mexican Wolf Recovery Area: Implications for Livestock Management and Carnivore Compensation Schemes. *Biological Conservation* [p40]

Decesare N, Wilson S, Bradley E, Gude J, Inman R, Lance N, Laudon K, Nelson A, Ross M, Smucker T. 2018. Wolf-Livestock Conflict and the Effects of Wolf Management. *Journal of Wildlife Management* [p49]

Ditmer M, Werden L, Tanner J, Vincent J, Callahan P, Laizzo P, Laske T, Garshelis D. 2019. Bears Habituate to the Repeated Exposure of a Novel Stimulus, Unmanned Aircraft Systems. *Conservation Physiology* [p53]

Elfstrom M, Zedrosser A, Stoen O-G, Swenson JE. 2014. Ultimate and Proximate Mechanisms Underlying the Occurrence of Bears Close to Human Settlements: Review and Management Implications. *Mammal Review* [p54]

Evans MJ, Hawley JH, Rego PW, Rittenhouse TAG. 2014. Exurban Land Use Facilitates Human-Black Bear Conflicts. *Journal of Wildlife Management* [p55]

Fowler NL, Belant JL, Beyer DE. 2019. Non-Linear Relationships Between Human Activities and Wolf-Livestock Depredations. *Biological Conservation* [p56]

Gaynor K, Hajnowski C, Carter N, Brashares J. 2018. The Influence of Human Disturbance on Wildlife Nocturnality. *Science* [p57]

Grilo C, Lucas PM, Fernández-Gil A, Seara M, Costa G, Roque S, Rio-Maior H, Nakamura M, Álvares F, Petrucci-Fonseca F, Revilla E. 2018. Refuge as a Major Habitat Driver for Wolf Presence in Human-Modified Landscapes. *Animal Conservation* [p60]

Gunther KA, Haroldson MA, Frey K, Cain SL, Copeland J, Schwartz C. 2004. Grizzly Bear-Human Conflicts in the Greater Yellowstone Ecosystem, 1992-2000. *Ursus* [p60]

Hanley Z, Cooley H, Maletzke B, Wielgus R. 2018. Cattle Depredation Risk by Gray Wolves on Grazing Allotments in Washington. *Global Ecology and Conservation* [p62]

Hanley Z, Cooley H, Maletzke B, Wielgus R. 2018. Forecasting Cattle Depredation Risk by Recolonizing Grey Wolves. *Wildlife Biology* [p62]

Haswell PM, Shepherd EA, Stone SA, Purcell B, Hayward MW. 2019. Foraging Theory Provides a Useful Framework for Livestock Predation Management. *J Nat Conserv* [p63]

Hebblewhite M. 2011. Unreliable Knowledge about Economic Impacts of Large Carnivores on Bovine Calves. *Journal of Wildlife Management* [p63]

Hiller TL, McFadden-Hiller JE, Jenkins SR, Belant JL, Tyre AJ. 2015. Demography, Prey Abundance, and Management Affect Number of Cougar Mortalities Associated with Livestock Conflict. *Journal of Wildlife Management* [p64]

Holland KK, Larson LR, Powell RB. 2018. Characterizing Conflict Between Humans and Big Cats *Panthera spp*: A Systematic Review of Research Trends and Management Opportunities. *PLoS ONE* [p65]

Johnson H, Lewis D, Verzuh T, Wallace C, Much R, Willmarth L, Breck S. 2017. Human Development and Climate Affect Hibernation in a Large Carnivore with Implications for Human–Carnivore Conflicts. *J Appl Ecol* [p68]

Kertson BN, Spencer RD, Marzluff JM, Hepinstall-Cymerman J, Grue CE. 2011. Cougar Space Use and Movements in the Wildland-Urban Landscape of Western Washington. *Ecological Applications* [p69]

Kompaniyets L and Evans MA. 2017. Modeling the Relationship between Wolf Control and Cattle Depredation. *PLoS ONE* [p72]

Lambert CMS, Wielgus RB, Robinson HS, Katnik DD, Cruickshank HS, Clark R, Almack J. 2006. Cougar population dynamics and viability in the Pacific Northwest. *Journal of Wildlife Management* [p74]

Laporte I, Muhly TB, Pitt JA, Alexander M, Musiani M. 2010. Effects of Wolves on Elk and Cattle Behaviors: Implications for Livestock Production and Wolf Conservation. *PLoS ONE* [p76]

Mattson DJ, Logan K, Sweanor L. 2011. Factors Governing Risk of Cougar Attacks on Humans. *Human-Wildlife Interactions* [p85]

Miller JRB. 2015. Mapping Attack Hotspots to Mitigate Human-Carnivore Conflict: Approaches and Applications of Spatial Predation Risk Modeling. *Biodivers Conserv* [p86]

Morehouse AT, Boyce MS. 2011. From Venison to Beef: Seasonal Changes in Wolf Diet Composition in a Livestock Grazing Landscape. *Frontiers in Ecology and the Environment* [p87]

Morehouse A, Boyce M. 2017. Troublemaking Carnivores: Conflicts with Humans in a Diverse Assemblage of Large Carnivores. *Ecology and Society* [p88]

Morehouse AT, Graves TA, Mickle N, Boyce MS. 2016. Nature vs. Nurture: Evidence for Social Learning of Conflict Behavior in Grizzly Bears. *PLoS ONE* [p88]

Muhly, TB., Musiani, M. 2009. Livestock Depredation by Wolves and the Ranching Economy in the Northwestern U.S. *Ecological Economics* [p91]

Musiani M, Muhly T, Gates CC, Callaghan C, Smith ME, Tosoni E. 2005. Seasonality and Reoccurrence of Depredation and Wolf Control in Western North America. *Wildlife Society Bulletin* [p93]

Nelson AA, Kauffman MJ, Middleton AD, Jimenez MD, McWhirter DE, Barber J, Gerow K. 2012. Elk Migration Patterns and Human Activity Influence Wolf Habitat Use in the Greater Yellowstone Ecosystem. *Ecological Applications* [p95]

Nelson AA, Kauffman MJ, Middleton AD, Jimenez MD, McWhirter DE, Gerow K. 2016. Native Prey Distribution and Migration Mediates Wolf (*Canis lupus*) Predation on Domestic Livestock in Greater Yellowstone Ecosystem. *Canadian Journal of Zoology* [p95]

Northrup J, Stenhouse G, Boyce M. 2012. Agricultural Lands as Ecological Traps for Grizzly Bears. *Animal Conservation* [p98]

Obbard ME, Howe EJ, Wall LL, Allison B, Black R, Davis P, Dix-Gibson L, Gatt M, Hall MN. 2014. Relationships Among Food Availability, Harvest, and Human-Bear Conflict at Landscape Scales in Ontario, Canada. *Ursus* [p99]

Olson ER, Van Deelen TR, Wydeven AP, Ruid DB, MacFarland DM, Ventura SJ. 2019. A Landscape of Overlapping Risks for Wolf-Human Conflict in Wisconsin, USA. *Journal of Environmental Management* [p100]

Proctor M, Kasworm W, Annis K, MacHutchon A, Teisberg J, Radandt T, Servheen C. 2018. Conservation of Threatened Canada-USA Trans-border Grizzly Bears Linked to Comprehensive Conflict Reduction. *Human–Wildlife Interactions* [p103]

Ramler JP, Hebblewhite M, Kellenberg K, Sime C. 2014. Crying Wolf? A Spatial Analysis of Wolf Location and Depredations on Calf Weight. *American Journal of Agricultural Economics* [p104]

Reyna-Saenz F, Zarco-Gonzalez MM, Monroy-Vilchis O, Antonio-Nemiga X. 2019. Regionalization of Environmental and Anthropic Variables Associated to Livestock Predation by Large Carnivores in Mexico. *Animal Conservation* [p106]

Scasta J.D., Windh J, Stam B. 2018. Modeling Large Carnivore and Ranch Attribute Effects on Livestock Predation and Nonlethal Losses. *Rangeland Ecology and Management* [p113]

Schwartz CC, Haroldson MA, White GC. 2010. Hazards Affecting Grizzly Bear Survival in the Greater Yellowstone Ecosystem. *Journal of Wildlife Management* [p114]

Seoraj-Pillai N, Pillay N. 2017. A Meta-Analysis of Human-Wildlife Conflict: South African and Global Perspective. *Sustainability* [p115]

Stone SA, Breck SW, Timberlake J, Haswell PM, Najera F, Bean BS, Thornhill DJ. 2017. Adaptive Use of Nonlethal Strategies for Minimizing Wolf-Sheep Conflict in Idaho. *Journal of Mammalogy* [p123]

Treves, A., Naughton-Treves, L., Harper, E., Mladenoff, D., Rose, R., Sickley, T., Wydeven, A. 2004. Predicting Human-Carnivore Conflict: A Spatial Model Derived from 25 Years of Data on Wolf Predation on Livestock. *Conservation Biology* [p127]

Treves A, Rabenhorst M. 2017. Risk Map for Wolf Threats to Livestock Still Predictive 5 Years After Construction. *PLoS ONE* [p128]

Tucker M, Bohning-Gaese K, Fagan W, et al. 2018. Moving in the Anthropocene: Global Reductions in Terrestrial Mammalian Movements. *Science* [p129]

Ugarte CS, Moreira-Arce D, Simonetti JA. Ecological attributes of carnivore-livestock conflict. *Frontiers in Ecology and Evolution* [p130]

Vijayan S, Morris DW, McLaren BE, Mukherjee S. 2017. Domestic Ungulates in Protected Areas and the Potential for Indirect Interactions Via Shared Predation. *Biodiversity* [p132]

Wells S, McNew L, Tyers D, Manen F. 2018. Thompson D. Grizzly Bear Depredation on Grazing Allotments in the Yellowstone Ecosystem. *Journal of Wildlife Management* [p135]

Wielgus RB, Peebles KA. 2014. Effects of Wolf Mortality on Livestock Depredations. *PLoS ONE* [p136]

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Burchfield JA, Belsky JM. 2005. Natural Landscape Features, Human-Related Attractants, and Conflict Hotspots: A Spatial Analysis of Human-Grizzly Bear Conflicts. *Ursus* [p137]

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Merrill T. 2006. Landscape Conditions Predisposing Grizzly Bears to Conflicts on Private Agricultural Lands in the Western USA. *Biological Conservation* [p137]

Zarco-Gonzalez, M., Monroy-Vilchis, O., Rodriguez-Soto, C., Urios, V. 2012. Spatial Factors and Management Associated with Livestock Predations by *Puma concolor* in Central Mexico. *Human Ecology* [p141]

Policy, Governance, and Social Science

a. Policy & Governance

Bergstrom BJ. 2017. Carnivore Conservation: Shifting the Paradigm from Control to Coexistence. *Journal of Mammalogy* [p33]

Bergstrom BJ, Arias LC, Davidson AD, Ferguson AW, Randa LA, Sheffield SR. 2013. License to Kill: Reforming Federal Wildlife Control to Restore Biodiversity and Ecosystem Function. *Conservation Letters* [p33]

Browne-Nunez C, Treves A, MacFarland D, Voyles Z, Turnig C. 2015. Tolerance of Wolves in Wisconsin: A Mixed Methods Examination of Policy Effects on Attitudes and Behavioral Inclinations. *Biological Conservation* [p41]

Bruskotter JT, Enzler SA, Treves A. 2011. Rescuing Wolves from Politics: Wildlife as a Public Trust Resource. *Science* [p41]

Bruskotter JT, Fulton DC. 2012. Will Hunters Steward Wolves? A Comment on Treves and Martin. *Society and Natural Resources* [p42]

Chamberlain E, Rutherford M, Gibeau M. 2012. Human Perspectives and Conservation of Grizzly Bears in Banff National Park, Canada. *Conservation Biology* [p45]

Clark DA, Slocombe DS. 2011. Grizzly Bear Conservation in the Foothills Model Forest: Appraisal of a Collaborative Ecosystem Management Effort. *Policy Sciences* [p47]

Coleman TH, Schwartz CC, Gunther KA, Creel S. 2013. Grizzly Bear and Human Interaction in Yellowstone National Park: An Evaluation of Bear Management Areas. *Journal of Wildlife Management* [p47]

Coogan SCP, Coops NC, Janz DM, Cattet MRL, Kearney SP, Stenhouse GB, Nielsen SE. 2019. Towards Grizzly Bear Population Recovery in a Modern Landscape. *J Appl Ecol* [p48]

Decker D, Jacobson C, Brown T. 2006. Situation-Specific "Impact Dependency" as a Determinant of Management Acceptability: Insights from Wolf and Grizzly Bear Management in Alaska. *Wildlife Society Bulletin* [p50]

Dilkina B, Houtman R, Gomes CP, Montgomery CA, McKelvey KS, Kendall K, Graves TA, Bernstein R, Schwartz MK. 2016. Trade-offs and Efficiencies in Optimal Budget-Constrained Multispecies Corridor Networks. *Conservation Biology* [p52]

Epstein Y. 2017. Killing Wolves to Save Them? Legal Responses to Tolerance Hunting in European Union and United States. *RECEIL* [p54]

Evans MJ, Hawley JH, Rego PW, Rittenhouse TAG. 2014. Exurban Land Use Facilitates Human-Black Bear Conflicts. *Journal of Wildlife Management* [p55]

Fremier AK, Kiparsky M, Gmur S, Aycrigg J, Craig RK, Svancara LK, Goble DD, Cosens B, Davis FW, Scott JM. 2015. A Riparian Conservation Network for Ecological Resilience. *Biological Conservation* [p57]

Hughes C, Nielsen SE. 2019. 'Bear are Only the Lightning Rod': Ongoing Acrimony in Alberta's Grizzly Bear Recovery. *Society and Natural Resources* [p65]

Jochum KA, Kliskey AA, Hundertmark KJ, Alessa L. 2014. Integrating Complexity in the Management of Human-Wildlife Encounters. *Global Environmental Change* [p67]

Lacher I, Wilkerson ML. 2013. Wildlife Connectivity Approaches and Best Practices in U.S. State Wildlife Action Plans. *Conservation Biology* [p72]

Larson S, McGranahan DA, Timm RM. 2019. The Marin County Livestock Protection Program: 15 Years in Review. *Human-Wildlife Interactions* [p77]

Lute M, Carter N, Lopez-Bao J, Linnell J. 2018. Conservation Professionals Agree on Challenges to Coexisting with Large Carnivores but Not on Solutions. *Biological Conservation* [p80]

Lute ML, Gore ML. 2014. Knowledge and Power in Wildlife Management. *Journal of Wildlife Management* [p80]

Miller JRB. 2015. Mapping Attack Hotspots to Mitigate Human-Carnivore Conflict: Approaches and Applications of Spatial Predation Risk Modeling. *Biodivers Conserv* [p86]

Muhly TB, Dubois M. 2013. Advancing the Management of Carnivore Predation on Livestock in Western Canada. *Human Dimensions of Wildlife* [p91]

Nie MA. 2001. The Sociopolitical Dimensions of Wolf Management and Restoration in the United States. *Research in Human Ecology* [p95]

Nie MA. 2004. State Wildlife Policy and Management: The Scope and Bias of Political Conflict. *Public Administration Review* [p97]

Nie M, Barns C, Haber J, Joly J, Pitt K, Zellmer S. 2017. Fish and Wildlife Management on Federal Lands: Debunking State Supremacy. *Environmental Law* [p97]

Nyhus PJ. 2016. Human-Wildlife Conflict and Coexistence. *Annual Review of Environment and Resources* [p99]

Olson ER, Stenglein JL, Shelley V, Rissman AR, Browne-Nunez C, Voyles Z, Wydeven AP, Van Deelen T. 2014. Pendulum Swings in Wolf Management Led to Conflict, Illegal Kills, and a Legislated Wolf Hunt. *Conservation Letters* [p100]

Ordiz A, Bischof R, Swenson JE. 2013. Saving Large Carnivores, but Losing the Apex Predator? *Biological Conservation* [p101]

Primm SA, Wilson SM. 2004. Reconnecting Grizzly Bear Populations: Prospects for Participatory Projects. *Ursus* [p103]

Redpath SM, Linnell JDC, Festa-Bianchet M, Boitani L, Bunnefeld N, Dickman A, Gutierrez RJ, Irvine JR, Johansson M, Majic A, McMahon BJ, Pooley S, Sandstrom C, Sjolander-Lindqvist A, Skogen K, Swenson JE, Trouwborst A, Young J, Milner-Gulland EJ. 2017. Don't Forget to Look Down—Collaborative Approaches to Predator Conservation. *Biological Reviews* [p106]

Steele JR, Rashford BS, Foulke TK, Tanaka JA, Taylor DT. 2013. Wolf (Canis lupus) Predation Impacts on Livestock Production: Direct Effects, Indirect Effects, and Implications for Compensation Ratios. *Rangeland Ecol Manage* [p121]

Stenglein JL, Wydeven AP, Van Deelen TR. 2018. Compensatory Mortality in a Recovering Top Carnivore: Wolves in Wisconsin, USA (1979-2013). *Oeacologia* [p122]

Suzuki N, Parker KL. 2016. Potential Conflict Between Future Development of Natural Resources and High-Value Wildlife Habitats in Boreal Landscapes. *Biodivers Conserv* [p123]

Treves A, Artelle K, Paquet P. 2018. Differentiating Between Regulation and Hunting as Conservation Interventions. *Conservation Biology* [p125]

Treves A, Chapron G, Lopez-Bao JV, Shoemaker C, Goeckner AR, Bruskotter JT. 2015. Predators and the Public Trust. *Biological Reviews* [p125]

Treves A, Krofel M, McManus J. 2016. Predator Control Should Not Be a Shot in the Dark. *Frontiers in Ecology and the Environment* [p126]

Treves A, Martin KA. 2011. Hunters as Stewards of Wolves in Wisconsin and the Northern Rocky Mountains, USA. *Society and Natural Resources* [p126]

Treves, A., Naughton-Treves, L., Harper, E., Mladenoff, D., Rose, R., Sickley, T., Wydeven, A. 2004. Predicting Human-Carnivore Conflict: a Spatial Model Derived from 25 Years of Data on Wolf Predation on Livestock. *Conservation Biology* [p127]

Treves A, Wallace RB, White S. 2009. Participatory Planning of Interventions to Mitigate Human-Wildlife Conflicts. *Conservation* Biology [p129]

Vernon ME, Bischoff-Mattson Z, Clark SG. 2016. Discourses of Elk Hunting and Grizzly Bear Incidents in Grand Teton National Park, Wyoming. *Human Dimensions of Wildlife* [p132]

Way J, Bruskotter J. 2012. Additional Considerations for gray wolf management after their removal from endangered species act protections. *Journal of Wildlife Management* [p135]

b. Social Science

Baruch-Mordo S, Breck SW, Wilson KR, Broderick J. 2009. A Tool Box Half Full: How Social Science Can Help Solve Human-Wildlife Conflict. *Human Dimensions of Wildlife* [p30]

Bennett NJ, Roth R, Klain SC, Chan K, Christie P, Clark DA, Cullman G, Curran D, Durbin TJ, Epstein G, Greenberg A, Nelson MP, Sandlos J, Stedman R, Teel RL, Thomas R, Verissimo I, Wyborn C. 2016. Conservation Social Science: Understanding and Integrating Human Dimensions to Improve Conservation. *Biological Conservation* [p31]

Berkes F. 2004. Rethinking Community-Based Conservation. *Conservation Biology* [p33]

Bontrager A, Kretser H, Leong K, Connelly N. 2017. Conservation Opportunity and Risk Mapping for Carnivores Using Landowner Survey Data from the Greater Yellowstone Ecosystem. *Professional Geographer* [p37]

Bruskotter JT, Toman E, Enzler SA, Schmidt RH. 2010. Are Gray Wolves Endangered in the Northern Rocky Mountains? A Role for Social Science in Listing Determinations. *BioScience* [p42]

Bruskotter J, Vaske J, Schmidt R. 2009. Social and Cognitive Determinants of Utah Residents' Acceptance of the Lethal Control of Wolves. *Human Dimensions of Wildlife* [p42]

Bruskotter JT, Vucetich JA, Manfredo MJ, Karns GR, Wolf C, Ard K, Carter NH, López-Bao JV, Chapron G, Gehrt S, Ripple WJ. 2017. Modernization, Risks, and Conservation of the World's Largest Carnivores. *BioScience* [p43]

Carroll C, Rohlf DJ, Li Y-W, Phillips MK, Noss RF. 2014. Connectivity Conservation and Endangered Species Recovery: A Study in the Challenges of Defining Conservation-Reliant Species. *Conservation Letters* [p44]

Crook SES. 2014. Information Spread in a Region of Human-Mountain Lion Coexistence. *Human Dimensions of Wildlife* [p49]

Dickman AJ. 2010. Complexities of Conflict: The Importance of Considering Social Factors for Effectively Resolving Human-Wildlife Conflict. *Animal Conservation* [p50]

Dickman A, Marchini S, Manfredo M. 2013. The Human Dimension in Addressing Conflict with Large Carnivores. *ResearchGate* [p51]

Dietsch AM, Teel TL, Manfredo MJ. 2016. Social Values and Biodiversity Conservation in a Dynamic World. *Conservation Biology* [p52]

Gilbert S, Sivy K, Pozzengharra C, DuBour A, Overduijn K, Smith MM, Zhou J, Little JM, Prugh LR. 2016. Socioeconomic Benefits of Large Carnivore Recolonization Through Reduced Wildlife-Vehicle Collisions. *Conservation Letters* [p58]

Hogberg J, Treves A, Shaw B, Naughton-Treves L. 2014. Changes in Attitudes Toward Wolves Before and After an Inaugural Public Hunting and Trapping Season: Early Evidence from Wisconsin's Wolf Range. *Environmental Conservation* [p64]

Johansson M, Merreira IA, Stoen O-G, Frank J, Flykt A. 2016. Targeting Human Fear of Large Carnivores—Many Ideas but Few Known Effects. *Biological Conservation* [p67]

Killion AK, Melvin T, Lindquist E, Carter NH. 2018. Tracking a Half Century of Media Reporting on Gray Wolves. *Conservation Biology* [p70]

Knopff AA, Knopff KH, St. Clair CC. 2016. Tolerance for Cougars Diminished by High Perception of Risk. *Ecology and Society* [p71]

Landon AC, Jacobs MH, Miller CA, Vaske JJ, Williams BD. 2019. Cognitive and Affective Predictors of Illinois Residents' Perceived Risks from Gray Wolves. *Society & Natural Resources* [p75]

Lischka ST, Teel TL, Johnson HE, Crooks KR. 2019. Understanding and Managing Human Tolerance for a Large Carnivore in a Residential System. *Biological Conservation* [p78]

Lopez Bao J, Bruskotter J. 2017. Finding Space for Large Carnivores. *Nature Ecology and Evolution*

Lozano J, Olszanska A, Morales-Reyes Z, Castro AA, Malo AF, Moleón M, Sanchez-Zapata JA, Cortés-Avizanda A, von Wehrden H, Dorresteijn I, Kansky R, Fischer J, Martín-López B. 2019. Human-Carnivore Relations: A Systematic Review. *Biological Conservation* [p79]

Lute ML, Gore ML. 2014. Stewardship as a Path to Cooperation? Exploring the Role of Identity in Intergroup Conflict Among Michigan Wolf Stakeholders. *Human Dimensions of Wildlife* [p81]

Lute ML, Navarrete CD, Nelson MP, Gore ML. 2016. Moral Dimensions of Human-Wildlife Conflict. *Conservation Biology* [p81]

Madden F. 2007. Creating Coexistence Between Humans and Wildlife: Global Perspectives on Local Efforts to Address Human-Wildlife Conflict. *Human Dimensions of Wildlife* [p82]

Madden F, McQuinn, B. 2014. Conservation's Blind Spot: The Case for Conflict Transformation in Wildlife Conservation. *Biological Conservation* [p83]

Manfredo M, Teel L, Sullivan L, Dietsch A. 2017. Values, Trust, and Cultural Backlash in Conservation Governance: The Case of Wildlife Management in the United States**.** *Biological Conservation* [p84]

Mattson DJ, Byrd KL, Rutherford MB, Brown SR, Clark TW. 2006. Finding Common Ground in Large Carnivore Conservation: Mapping Contending Perspectives. *Environmental Science and Policy* [p84]

Mattson DJ, Ruther EJ. 2012. Explaining Puma-Related Behaviors and Behavioral Intentions Among Northern Arizona Residents. *Human Dimensions of Wildlife* [p85]

Morehouse A, Boyce M. 2017. Troublemaking Carnivores: Conflicts with Humans in a Diverse Assemblage of Large Carnivores. *Ecology and Society* [p88]

Naughton-Treves L, Grossberg R, Treves A. 2003. Paying for tolerance: Rural Citizens' Attitudes Toward Wolf Depredation and Compensation. *Conservation Biology* [p94]

Nie MA. 2002. Wolf Recovery and Management as Value-Based Political Conflict. *Ethics, Place and Environment* [p96]

Parker ID, Feldpausch-Parker AM. 2013. Yellowstone Grizzly Delisting Rhetoric: An Analysis of the Online Debate. *Wildlife Society Bulletin* [p101]

Richie L, Oppenheimer JD, Clark SG. 2012. Social Process in Grizzly Bear Management: Lessons for Collaborative Governance and Natural Resource Policy. *Policy Sciences* [p107]

Rutherford MB, Gibeau ML, Clark SG, Chamberlain EC. 2009. Interdisciplinary Problem Solving Workshops for Grizzly Bear Conservation in Banff National Park, Canada. *Policy Sciences* [p110]

Slagle K, Bruskotter JT, Singh AS, Schmidt RH. 2017. Attitudes Toward Predator Control in the United States: 1995-2014. *Journal of Mammalogy* [p117]

Slagle K, Bruskotter J, Wilson R. 2012. The Role of Affect in Public Support and Opposition to Wolf Management. *Human Dimensions of Wildlife* [p117]

Slagle K, Zajac R, Bruskotter J, Wilson, R, Prange S. 2012. Building Tolerance for Bears: A Communications Experiment. *Journal of Wildlife Management and Wildlife Monographs* [p118]

Sponarski CC, Semeniuk C, Glikman JA, Bath AJ, Musiani M. 2013. Heterogeneity among Rural Resident Attitudes Toward Wolves. *Human Dimensions of Wildlife* [p121]

Treves A, Naughton-Treves L, Shelley V. 2013. Longitudinal Analyses of Attitudes Towards Wolves. *Conservation Biology* [p128]

Vucetich JA, Bruskotter JT, Nelson MP, Peterson RO, Bump JK. 2017. Evaluating the Principles of Wildlife Conservation: A Case Study of Wolf (*Canis lupis*) hunting in Michigan, United States. *Journal of Mammalogy* [p134]

Vucetich JA, Burnham D, Macdonald EA, Bruskotter JT, Marchini S, Zimmermann A, Macdonald DW. 2018. Just Conservation: What Is It and Should We Pursue It? *Biological Conservation* [p134]

Windh JL, Stam B, Scasta JD. 2019. Contemporary Livestock-Predator Themes Identified Through a Wyoming USA Rancher Survey. *Society for Range Management* [p138]

Young JK, Ma Z, Laudati A, Berger J. 2015. Human-Carnivore Interactions: Lessons Learned from Communities in the American West. *Human Dimensions of Wildlife* [p139]

Zajac RM, Bruskotter JT, Wilson RS, Prange S. 2012. Learning to Live with Black Bears: A Psychological Model of Acceptance. *Journal of Wildlife Management* [p141]

Lethal Control

Bergstrom BJ. 2017. Carnivore Conservation: Shifting the Paradigm from Control to Coexistence. *Journal of Mammalogy* [p33]

Bergstrom BJ, Arias LC, Davidson AD, Ferguson AW, Randa LA, Sheffield SR. 2013. License to Kill: Reforming Federal Wildlife Control to Restore Biodiversity and Ecosystem Function. *Conservation Letters* [p33]

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* [p38]

Brainerd SM, Andren H, Bangs EE, Bradley EH, Fontaine JA, Hall W, Iliopoulos Y, Jimenez MD, Jozwiak

EA, Liberg O, Mack CM, Meier TJ, Niemeyer CC, Pedersen HC, Sand H, Schultz RN, Smith DW, Wabakken P, Wydeven AP. 2008. The Effects of Breeder Loss on Wolves. *Journal of Wildlife Management* [p39]

Browne-Nunez C, Treves A, MacFarland D, Voyles Z, Turnig C. 2015. Tolerance of Wolves in Wisconsin: A Mixed Methods Examination of Policy Effects on Attitudes and Behavioral Inclinations. *Biological Conservation* [p41]

Bruskotter J, Vaske J, Schmidt R. 2009. Social and Cognitive Determinants of Utah Residents' Acceptance of the Lethal Control of Wolves. *Human Dimensions of Wildlife* [p42]

Chapron G, Treves A. 2016. Blood Does not Buy Goodwill: Allowing Culling Increases Poaching of a Large Carnivore. *Proc R Soc* [p45]

Decker D, Jacobson C, Brown T. 2006. Situation-Specific "Impact Dependency" as a Determinant of Management Acceptability: Insights from Wolf and Grizzly Bear Management in Alaska. *Wildlife Society Bulletin* [p50]

Kertson BN, Spencer RD, Marzluff JM, Hepinstall-Cymerman J, Grue CE. 2011. Cougar Space Use and Movements in the Wildland-Urban Landscape of Western Washington. *Ecological Applications* [p69]

Kompaniyets L and Evans MA. 2017. Modeling the Relationship between Wolf Control and Cattle Depredation. *PLoS ONE* [p72]

Lennox R, Gallagher A, Ritchie E, Cooke S. 2018. Evaluating the Efficacy of Predator Removal in a Conflict-Prone World. *Biological Conservation* [p78]

Miller JRB, Stoner KJ, Cejtin MR, Meyer TK, Middleton AD, Schmitz OJ. 2016. Effectiveness of Contemporary Techniques for Reducing Livestock Depredations by Large Carnivores. *Wildlife Society Bulletin* [p86]

Moreira-Arce D, Ugarte CS, Zorondo-Rodríguez F, Simonetti JA. 2018. Management Tools to Reduce Carnivore-Livestock Conflicts: Current Gap and Future Challenges. *Rangeland Ecology and Management* [p89]

Muhly TB, Dubois M. 2013. Advancing the Management of Carnivore Predation on Livestock in Western Canada. *Human Dimensions of Wildlife* [p91]

Musiani M, Muhly T, Gates CC, Callaghan C, Smith ME, Tosoni E. 2005. Seasonality and Reoccurrence of Depredation and Wolf Control in Western North America. *Wildlife Society Bulletin* [p93]

Naughton-Treves L, Grossberg R, Treves A. 2003. Paying for tolerance: Rural Citizens' Attitudes Toward Wolf Depredation and Compensation. *Conservation Biology* [p94]

Rich LN, Mitchell M S, Gude JA, Sime CA. 2012. Anthropogenic Mortality, Intraspecific Competition, and Prey Availability Influence Territory Sizes of Wolves in Montana. *Journal of Mammalogy* [p107]

Santiago-Avila F, Cornman A, Treves A. 2018. Killing Wolves to Prevent Predation on Livestock May Protect One Farm but Harm Neighbors. *PLoS ONE* [p111]

Scasta J.D., Stam B, Windh J.L. 2017. Rancher-Reported Efficacy of Lethal and Non-Lethal Livestock Predation Mitigation Strategies for a Suite of Carnivores. *Scientific Reports* [p113]

Slagle K, Bruskotter JT, Singh AS, Schmidt RH. 2017. Attitudes Toward Predator Control in the United States: 1995-2014. *Journal of Mammalogy* [p117]

Stenglein JL, Wydeven AP, Van Deelen TR. 2018. Compensatory Mortality in a Recovering Top Carnivore: Wolves in Wisconsin, USA (1979-2013). *Oeacologia* [p122]

Teichman KJ, Cristescu B, Darimont CT. 2016. Hunting as a Management Tool? Cougar-Human Conflict is Positively Related to Trophy Hunting. *BMC Ecology* [p124]

Treves A, Krofel M, McManus J. 2016. Predator Control Should Not Be a Shot in the Dark. *Frontiers in Ecology and the Environment* [p126]

Van Eeden LM, Eklund A, Miller JRB, López-Bao J, Chapron G, Cejtin MR, Crowther MS, Dickman CR, Frank J, Krofel M, Macdonald DW, McManus J, Meyer TK, Middleton AD, Newsome TM, Ripple WJ, Ritchie EG, Schmitz OJ, Stoner KJ, Tourani M, Treves A. 2018. Carnivore Conservation Needs Evidence-Based Livestock Protection. *PLoS Biology* [p131]

Way J, Bruskotter J. 2012. Additional Considerations for Gray Wolf Management after Their Removal from Endangered Species Act Protections. *Journal of Wildlife Management* [p135]

Wielgus RB, Peebles KA. 2014. Effects of Wolf Mortality on Livestock Depredations. *PLoS ONE* [p136]

Nonlethal & Preventative Tools

Allen BL, Allen LR, Ballard G, Druilly M, Fleming PJS, Hampton JO, Hayward MW, Kerley GIH, Meek PD, Minnie L, O'Riain MJ, Parker DM, Somers MJ. 2019. Animal Welfare Considerations for Using Large Carnivores and Guardian Dogs as Vertebrate Biocontrol Tools Against Other Animals. *Biological Conservation* [p27]

Andelt WF. 2004. Use of Livestock Guarding Animals to Reduce Predation on Livestock. *Sheep and Goat Research Journal* [p28]

Bergstrom BJ. 2017. Carnivore Conservation: Shifting the Paradigm from Control to Coexistence. *Journal of Mammalogy* [p33]

Bergstrom BJ, Arias LC, Davidson AD, Ferguson AW, Randa LA, Sheffield SR. 2013. License to Kill: Reforming Federal Wildlife Control to Restore Biodiversity and Ecosystem Function. *Conservation Letters* [p33]

Blackwell BF, DeVault TL, Fernandez-Juricic E, Gese EM, Gilbert-Norton L, Breck SW. 2016. No Single Solution: Application of Behavioural Principles in Mitigating Human-Wildlife Conflict. *Animal Behaviour* [p34]

Bradley EH, Pletscher DH, Bangs EE, Kunkel KE, Smith DW, Mack CM, Meier TJ, Fontaine JA, Niemeyer

CC, Jimenez MD. 2005. Evaluating Wolf Translocation as a Nonlethal Method to Reduce Livestock Conflicts in the Northwestern United States. *Conservation Biology* [p38]

Breck SW, Clark P, Howery L, Johnson D, Kluever BM, Smallidge S, Cibils AF. 2012. A Perspective on Livestock-Wolf Interactions on Western Rangelands. *Rangelands* [p39]

Breck SW, Kluever BM, Panasci M, Oakleaf J, Johnson T, Howery L, Bergman DL. 2011. Domestic Calf Mortality and Producer Detection Rates in the Mexican Wolf Recovery Area: Implications for Livestock Management and Carnivore Compensation Schemes*. Biological Conservation* [p40]

Ditmer M, Werden L, Tanner J, Vincent J, Callahan P, Laizzo P, Laske T, Garshelis D. 2019. Bears Habituate to the Repeated Exposure of a Novel Stimulus, Unmanned Aircraft Systems. *Conservation Physiology* [p53]

Eklund A, López-Bao JV, Tourani M, Chapron G, Frank J. 2017. Limited Evidence on the Effectiveness of Interventions to Reduce Livestock Predation by Large Carnivores. *Scientific Reports* [p54]

Gehring TM, VerCauteren KC, Landry J. 2010. Livestock Protection Dogs in the 21st Century: Is an Ancient Tool Relevant to Modern Conservation Challenges? *BioScience* [p58]

Gehring TM, VerCauteren KC, Cellar AC. 2011. Good Fences Make Good Neighbors: Implementation of Electric Fencing for Establishing Effective Livestock-Protection Dogs. *Human-Wildlife Interactions* [p58]

Hanley Z, Cooley H, Maletzke B, Wielgus R. 2018. Forecasting Cattle Depredation Risk by Recolonizing Grey Wolves. *Wildlife Biology* [p62]

Holland KK, Larson LR, Powell RB. 2018. Characterizing Conflict Between Humans and Big Cats *Panthera spp*: A Systematic Review of Research Trends and Management Opportunities. *PLoS ONE* [p65]

Johansson M, Merreira IA, Stoen O-G, Frank J, Flykt A. 2016. Targeting Human Fear of Large Carnivores—Many Ideas but Few Known Effects. *Biological Conservation* [p67]

Khorozyan I, Waltert M. 2019. A Framework of Most Effective Practices in Protecting Human Assets from Predators. *Human Dimensions of Wildlife* [p70]

Kinka D, Young JK. 2019. Evaluating Domestic Sheep Survival with Different Breeds of Livestock Guardian Dogs. *Rangeland Ecology & Management* [p71]

Kinka D, Young JK. 2018. A Livestock Guardian Dog by Any Other Name: Similar Response to Wolves Across Livestock Guardian Dog Breeds. *Rangeland Ecology and Management* [p71]

Lance NJ, Breck SW, Sime C, Callahan P, Shivik JA. 2010. Biological, technical, and social aspects of applying electrified fladry for livestock protection from wolves. *Wildlife Research* [p75]

Miller JRB, Stoner KJ, Cejtin MR, Meyer TK, Middleton AD, Schmitz OJ. 2016. Effectiveness of Contemporary Techniques for Reducing Livestock Depredations by Large Carnivores. *Wildlife Society Bulletin* [p86]

Morehouse AT, Boyce MS. 2011. From Venison to Beef: Seasonal Changes in Wolf Diet Composition in a Livestock Grazing Landscape. *Frontiers in Ecology and the Environment* [p87]

Morehouse AT, Graves TA, Mickle N, Boyce MS. 2016. Nature vs. Nurture: Evidence for Social Learning of Conflict Behavior in Grizzly Bears. *PLoS ONE* [p88]

Moreira-Arce D, Ugarte CS, Zorondo-Rodríguez F, Simonetti JA. 2018. Management Tools to Reduce Carnivore-Livestock Conflicts: Current Gap and Future Challenges. *Rangeland Ecology and Management* [p89]

Much R, Breck S, Lance N, Callahan P. 2018. An Ounce of Prevention: Quantifying the Effects of Non-Lethal Tools on Wolf Behavior. *Applied Animal Behavior Sciences* [p90]

Murray MH, Fassina S, Hopkins JB, Whittington J, St. Clair CC. 2017. Seasonal and Individual Variation in the Use of Rail-Associated Food Attractants by Grizzly Bears (*Ursus arctos*) in a National Park. *PLoS ONE* [p92]

Musiani M, Mamo C, Biotani L, Callaghan C, Gates CC, Mattei L, Visalberghi E, Breck S, Volpi G. 2003. Wolf Depredation Trends and the Use of Fladry Barriers to Protect Livestock in Western North America. *Conservation Biology* [p93]

Proctor M, Kasworm W, Annis K, MacHutchon A, Teisberg J, Radandt T, Servheen C. 2018. Conservation of Threatened Canada-USA Trans-border Grizzly Bears Linked to Comprehensive Conflict Reduction. *Human–Wildlife Interactions* [p103]

Santiago-Avila F, Cornman A, Treves A. 2018. Killing Wolves to Prevent Predation on Livestock May Protect One Farm but Harm Neighbors. *PLoS ONE* [p111]

Scasta J.D., Stam B, Windh J.L. 2017. Rancher-Reported Efficacy of Lethal and Non-Lethal Livestock Predation Mitigation Strategies for a Suite of Carnivores. *Scientific Reports* [p113]

Shivik JA. 2006. Tools for the Edge: What's New for Conserving Carnivores. *BioScience* [p116]

Shivik JA, Treves A, Callahan P. 2003. Nonlethal Techniques for Managing Predation: Primary and Secondary Repellents. *Conservation Biology* [p116]

Slagle K, Bruskotter JT, Singh AS, Schmidt RH. 2017. Attitudes Toward Predator Control in the United States: 1995-2014. *Journal of Mammalogy* [p117]

Smith ME, Linnell JDC, Odden J, Swenson JE. 2000. Review of Methods to Reduce Livestock Depredation: I. Guardian animals. *Acta Agriculturae Scandinavica* [p119]

Snijders L, Greggor AL, Hilderink F, Doran C. 2019. Effectiveness of Animal Conditioning Interventions in Reducing Human–Wildlife Conflict: a Systematic Map Protocol. *Environ Evid* [p120]

Stone SA, Breck SW, Timberlake J, Haswell PM, Najera F, Bean BS, Thornhill DJ. 2017. Adaptive Use of Nonlethal Strategies for Minimizing Wolf-Sheep Conflict in Idaho. *Journal of Mammalogy* [p123]

Treves A, Krofel M, McManus J. 2016. Predator Control Should Not Be a Shot in the Dark. *Frontiers in Ecology and the Environment* [p126]

Urbigkit C, Urbigkit J. 2010. A Review: The Use of Livestock Protection Dogs in Association with Large Carnivores in the Rocky Mountains. *Sheep and Goat Research Journal* [p130]

Van Eeden L, Crowther M, Dickman C, MacDonald D, Ripple W, Ritchie E, Newsome T. 2017. Managing Conflict Between Large Carnivores and Livestock. *Conservation Biology* [p131]

Van Eeden L, Eklund A, Miller J, López-Bao J, Chapron G, et al. 2018. Carnivore Conservation Needs Evidence-Based Livestock Protection. *PLoS Biology* [p131]

Way J, Bruskotter J. 2012. Additional Considerations for Gray Wolf Management after Their Removal from Endangered Species Act Protections. *Journal of Wildlife Management* [p135]

Wielgus RB, Peebles KA. 2014. Effects of Wolf Mortality on Livestock Depredations. *PLoS ONE* [p136]

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Burchfield JA, Belsky JM. 2005. Natural Landscape Features, Human-Related Attractants, and Conflict Hotspots: A Spatial Analysis of Human-Grizzly Bear Conflicts. *Ursus* [p137]

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Merrill T. 2006. Landscape Conditions Predisposing Grizzly Bears to Conflicts on Private Agricultural Lands in the Western USA. *Biological Conservation* [p137]

Young JK, Hammill E, Breck SW. 2019. Interactions with Humans Shape Coyote Responses to Hazing. *Scientific Reports* [p139]

Young J, Miller E, Essex A. 2015. Evaluating Fladry Designs to Improve Utility as a Nonlethal Management Tool to Reduce Livestock Depredation. *Wildlife Society Bulletin* [p140]

Young J, Steuber J, Few A, Baca A, Strong Z. 2018. When Strange Bedfellows Go All in: A Template for Implementing Non-Lethal Strategies Aimed at Reducing Carnivore Predation of Livestock. *Animal Conservation* [p140]

Literature

Adams, M, Service C, Bateman A, Bourbonnais M, Artelle K, Nelson T, Paquet P, Levi T, Darimont C. 2017. Intrapopulation Diversity in Isotopic Niche over Landscapes: Spatial Patterns Inform Conservation of Bear–Salmon systems. *Ecosphere* 8(6):e01843. DOI:10.1002/ecs2.1843.

Protected areas aim to conserve regions of biodiversity and promote long-term ecological and genetic variation. Yet, they can only represent portions of the habitat of most communities and the populations comprising them. Individuals differ in how and where they acquire food resources, often resulting in markedly varied dietary niches within populations. Adams et al. (2017) argue that processes to identify candidate-protected areas might benefit from measuring intra-population variation in food sources, which requires tools to assess how individuals differ in their foraging across space.

To illustrate this landscape approach, Adams et al. used stable isotope analysis and kernel-weighted regression to examine spatial patterns of salmon consumption by grizzly and black bears from 1995 to 2014 in British Columbia, Canada. While Grizzly bears consumed more salmon than black bears, and males of both species consumed more salmon than females, protected areas on the coast captured no more habitat for bears with high-salmon diets than did unprotected areas.

The authors argue that to safeguard this predator/prey association that spans coastal and interior regions, conservation planners and practitioners can use this information to inform management across ecological and jurisdictional boundaries. Understanding spatial variation in ecological patterns of species, therefore, can inform and empower conservation solutions, such as the configuration of critical habitat, the size of protected areas, and their potential linkages.

Agarwala M, Kumar S, Treves A, Naughton-Treves L. 2010. Paying for Wolves in Solapur, India, and Wisconsin, USA: Comparing Compensation Rules and Practices to Understand the Goals and Politics of Wolf Conservation. *Biological Conservation* 143:2945-55. DOI:10.1016/j.biocon.2010.05.003.

With growing pressure for conservation to pay its way, the merits of compensation for wildlife damage must be understood in diverse socioecological settings. Agarwala et al. compared compensation programs in Wisconsin, USA, and Solapur, India, where wolves survive in landscapes dominated by agriculture and pasture.

At both sites, rural citizens were especially negative toward wolves, even though other wild species caused more damage. Wisconsin and Solapur differ in payment rules and funding sources, which reflect distinct conservation and social goals.

In Wisconsin, as wolves recolonized the state, some periodically preyed on livestock and hunting dogs. Ranchers and some hunters were more likely to oppose wolves than were other citizens. The Wisconsin compensation program aimed to restore an iconic species by using voluntary contributions from wolf advocates to pay affected individuals more for wolf losses than for other species. By contrast, wolves had been continuously present in Solapur, and damages were distributed among the general populace. Government-supported compensation payments were on offer to anyone suffering losses, yet claims registered were low. There were no significant differences in attitudes of any particular segment of the population, but those losing high value livestock applied for compensation. Residents at both sites did

not report (Wisconsin) or expect (Solapur) a change in attitude toward wolves as a result of compensation, yet they support the existence of such programs.

To assess the merits of any compensation program, the authors suggest that those involved need to disentangle the multiple goals of compensation, such as reducing wolf killing or more fairly sharing the costs of conserving large carnivores.

Allen BL, Allen LR, Ballard G, Druilly M, Fleming PJS, Hampton JO, Hayward MW, Kerley GIH, Meek PD, Minnie L, O'Riain MJ, Parker DM, Somers MJ. 2019. Animal Welfare Considerations for Using Large Carnivores and Guardian Dogs as Vertebrate Biocontrol Tools Against Other Animals. *Biological Conservation* 232:258-70. DOI:*10.1016/j.biocon.2019.02.019*

Large carnivores and livestock guardian dogs are sometimes used as an alternative to traditional wildlife control options, using predation and/or fear of predation on targeted wildlife. While traditional approaches to wildlife management, such as fencing, shooting, trapping, and poisoning have been subject to formal assessment of their efficacy and animal welfare impacts, the welfare impacts of using large carnivores and livestock guardian dogs as biocontrol tools has not been sufficiently considered.

Allen et al. assessed the welfare impacts of using dingoes, leopards, and guardian dogs as biocontrol tools in Australia and South Africa using the 'Five Domains' approach. The authors conclude that while the welfare impacts of large carnivores and guardian dogs are dependent on specific predator-prey combinations, predation and/or fear of predation produces more harm to target animals than most traditional wildlife control tools. Since biocontrol tools are intentionally deployed by humans, the authors argue that they should be considered anthropogenic in origin and therefore require ethical scrutiny.

Allen J, Venter O, Watson M. 2017. Temporally Inter-Comparable Maps of Terrestrial Wilderness and the Last of the Wild. *Scientific Data* 7:10630-39. DOI:10.1038/sdata.2017.187

Wilderness areas—areas free of industrial-scale activities and other human pressures which result in significant biophysical disturbance—are important for biodiversity conservation and sustaining key ecological processes. Despite their importance, wilderness areas are being rapidly eroded and fragmented. Habitat conversion and fragmentation reduces dispersal abilities and functional traits among species, affecting survivability of individual species and entire ecosystems. Large mammalian carnivores often require large areas and adequate prey and foraging opportunities necessary for life history developments. Conserving wilderness areas supports survivability of large carnivores and a vast assemblage of other species.

In order to better capture the global extent of wilderness, Allen et al. utilized maps of human pressure on the natural environment to identify "pressure free" areas of wilderness likely operating in a natural state. In comparison with maps of recently observed human footprint, this data set represents the most intact ecosystems globally. This map and data set have important implications for the conservation of intact ecosystems, since damage in one area can affect the function of the entire system. The authors anticipate their maps to be important tools for identifying places where conservation actions must occur at the ecosystem scale and can help guide large-scale conservation efforts.

Amirkhiz RG, Frey JK, Cain JW, Breck SW, Bergman DL. 2018. Predicting Spatial Factors Associated with Cattle Depredations by the Mexican Wolf (*Canis lupus baileyi*) with Recommendations for Depredation Risk Modeling. *Biological Conservation* 224:327-35. DOI:10.1016/j.biocon.2018.06.013

The Mexican wolf (*Canis lupus baileyi*) was listed as endangered in 1976 when the wild last individuals were captured in Mexico to be part of a captive breeding program. Captive-bred Mexican wolves were released in 1998 into a recovery zone in the Apache National Forest, and have since dispersed throughout the Blue Range Wolf Recovery Area (BRWRA) and, as of 2015, the Mexican Wolf Experimental Population Area (MWEPA), which includes large areas of Arizona and New Mexico. Wolf populations have gradually increased, and this new expansion of territory has led to conflicts with livestock. Predation on livestock is one of the primary concerns for Mexican wolf recovery because it causes economic losses and negative attitudes towards wolves.

Prevention of conflicts depends on recognizing the conditions that produce the conflicts. Amirkhiz et al. developed a risk model of Mexican wolf depredation on livestock in Arizona and New Mexico in order to identify areas with relatively high potential for future cattle depredations. The authors considered landscape and human variables as well as biotic variables, such as the abundance of deer and elk. The two primary factors associated with high depredation risk included higher canopy cover variation and higher relative abundance of elk.

The resulting risk map indicates potential depredation hotspots and can be used to inform future management decisions. The authors suggest that spatial risk modeling can help reduce negative human-wildlife interactions by providing an early warning, and therefore an opportunity to prevent conflicts from occurring.

Andelt WF. 2004. Use of Livestock Guarding Animals to Reduce Predation on Livestock. *Sheep and Goat Research Journal* 19:72-75.

Livestock guarding dogs have been reported to effectively deter coyotes, mountain lions, and black and grizzly bears from livestock (although there is conflicting testimony as to their effectiveness with wolves). Time saved in herd management is reportedly often greater than time required to feed and work guarding dogs, and guarding dogs generally reduce reliance on lethal predator control techniques. Dogs are adaptable to many rangeland conditions and are effective across a range of pasture sizes and types. Donkeys and llamas have also been successfully deployed to reduce predator conflicts with livestock. They are typically used to protect sheep from coyotes.

Andelt studied the use of guarding animals and found that each animal type can confer some disadvantages. Some dog breeds can be aggressive toward people, and they are always susceptible to injury and premature death—disadvantages that are relatively uncommon, but can impose a cost on a livestock producer. Andelt found that donkeys and llamas can be introduced into herds of sheep at low cost with little or no added upkeep expense; however, they often react very aggressively toward canids, and are, by and large, a much less effective deterrent than dogs—and considered ineffectual in confrontations with wolves or bears.

Andelt argues that guarding animals are effective tools for mitigating livestock depredation, and that guarding dogs are a particularly cost-effective way of reducing predation in many situations.

Apps CD, McLellan BN, Proctor MF, Stenhouse GB, Serveen C. 2016. Predicting Spatial Variation in Grizzly Bear Abundance to Inform Conservation. *Journal of Wildlife Management* 80(3):396-413. DOI:10.1002/jwmg.1037.

Grizzly bear management and conservation is a highly publicized and politically charged issue, especially near the southern fringe of the species' range where human presence, activities, and development are prevalent and often increasing. Understanding of spatial structure of populations is fundamental to effective assessment, planning, and management for species conservation.

Apps et al. evaluated landscape composition relative to grizzly bear detection based on independent surveys conducted in the area (southeastern British Columbia and southwestern Alberta) between 1996 and 2010. Their underlying goal was to provide a foundation for regional management, conservation planning, and recovery efforts, whereby specific population estimates can be derived for any area, and population core, and peripheral and linkage landscapes can be inferred and assigned conservation priorities and strategies.

Apps et al. argue that spatial predictions for any defined population are likely to be more reliable than those extrapolated from tracking data of individual animals given limitations typical of such sampling. And that, ultimately, model output provides regional population context for environmental assessment, management, and conservation planning, nested within what should be finer-scale data and prediction where available.

Artelle KA, Anderson SC, Reynolds JD, Cooper AB, Paquet PC, Darimont CT. 2016. Ecology of Conflict: Marine Food Supply Affects Human-Wildlife Interactions on Land. *Scientific Reports* 6(25936). DOI:10.1038/srep25936

Research on the causes of human-wildlife conflicts typically focuses on proximate drivers, exposing important information for understanding specific conflicts. However, proximate inquiry offers limited insight into broader conflict patterns. In this study, Artelle et al. demonstrate how investigating the larger ecological context of conflict may lead to a better mechanistic understanding of conflict and could aid in management decision-making.

The authors tested three conflicting hypotheses (problem individuals, regional population saturation, limited food supply) related to the ultimate drivers of human-grizzly bear conflict, taking a generalizable, ecological approach to exploring patterns of human-wildlife conflict. Using data from British Columbia, Canada, between 1960-2014, Artelle et al. found most support for the limited food supply hypothesis, with salmon availability being the annual variable with the greatest measured importance for explaining conflict prevalence. In grizzly populations that feed on spawning salmon, for each 50% decrease in annual salmon biomass there was an average 20% increase in bears killed due to conflicts with humans. Additionally, more than 80% of attacks on humans and conflict kills occurred after the approximate onset of hyperphagia, a period of high caloric demand.

The authors suggest that improved conflict management that addresses underlying stressors such as food availability could help managers better predict when and where conflicts are likely to occur, enabling a more-proactive approach to conflict prevention. This could reduce the impetus for lethal

responses. The authors also argue that successfully reducing human-wildlife conflicts requires management that spans ecosystems and jurisdictional boundaries.

Baruch-Mordo S, Breck SW, Wilson KR, Broderick J. 2009. A Tool Box Half Full: How Social Science Can Help Solve Human-Wildlife Conflict. *Human Dimensions of Wildlife* 14(3):219-23. DOI:10.1080/10871200902839324.

There is a growing recognition among wildlife managers that focusing human-wildlife conflict management on just wildlife often provides a temporary fix, whereas changing human behavior can provide long-term solutions.

Baruch-Mordo et al. provide some insight into the importance of integrating human dimensions into conflict management, and some of the work done to date through direct observation of human behavior and self-reported behavior—two methods currently employed to measure the success of management actions in changing human behaviors.

The authors point out their own interest in improving our ability to manage wildlife by broadening understand of human dimensions work. They call on social scientists to help in this effort by implementing applied experiments that evaluate the efficacy of management actions aimed at changing human behavior. Additionally, they encourage researchers from both disciplines to develop collaborative efforts in order to better respond to current and future coexistence needs.

Baruch-Mordo S, Wilson KR, Lewis DL, Broderick J, Mao JS, Breck SW. 2014. Stochasticity in Natural Forage Production Affects Use of Urban Areas by Black Bears: Implications to Management of Human-Bear Conflicts. *PLOS ONE* 9(1):e85122. DOI:10.1371/journal.pone.0085122.

The rapid expansion of global urban development is increasing opportunities for wildlife to forage and become dependent on anthropogenic resources. Urbanization can affect individual wildlife and greater populations with negative effects including reduced survival and reproductive success, and positive effects including increased availability of food and cover and decreased predation pressure. Often, wildlife using urban areas are perceived dichotomously as urban or not, with some individuals removed in the belief that dependency on anthropogenic resources is irreversible and can lead to increased human-wildlife conflict.

Using six years of GPS location and activity data from bears in Aspen, CO, Baruch-Mordo et al. evaluated the degree of urbanization and the factors that best explain yearly variations in black bear habitation of urban areas. Results determined that space use and activity patterns in relation to the urbanized towns were dependent on natural food availability—in poor food years, bears used higher human density areas and became more nocturnal; in good food years, bears used wildland areas.

The authors suggest that bear use of urban areas is reversible and fluctuates with the availability of natural food resources, and that removal of urban individuals in times of food failures has the potential to negatively affect bear populations. The authors recommend that managers focus on reducing the availability of anthropogenic resources that attract bears to urban areas, e.g., garbage and fruit trees, thereby providing long-term solutions for the coexistence of people and bears.

Bautista C, Naves J, Revilla E, Fernandez N, Albrecht J, Scharf AK, Rigg R, Karamanlidis AA, Jerina k, Huber D, Palazon S, Kont R, Ciucci P, Groff C, Dutsov A, Seijas J, Quenette P-I, Olszanska A, Shkvyria M, Adamec M, Ozolins J, Jonozovic M, Selva N. 2017. Patterns and Correlates of Claims for Brown Bear Damage on a Continental Scale. *Journal of Applied Ecology* 54:282-92. DOI:10.1111/1365-2664.12708.

Wildlife damage to human property threatens human–wildlife coexistence. Conflicts arising from wildlife damage in intensively managed landscapes often undermine conservation efforts, making damage mitigation and compensation of special concern for wildlife conservation. However, the mechanisms underlying the occurrence of damage and claims at large scales are still poorly understood.

Bautista et al. investigated the patterns of damage caused by brown bears and its ecological and socio-economic correlates at a continental scale. The authors compiled information about compensation schemes across 26 countries in Europe from 2005–2012 and analyzed the variation in the number of compensated claims in relation to bear abundance, forest availability, human land use, management practices, and indicators of economic wealth. The mean number of compensated claims per bear and year ranged from 0 to 1 in Estonia to 5 to 8 in Norway. This variation was not only due to the differences in compensation schemes; damage claims were less numerous in areas proportion of agricultural land. However, observed variation in compensated damage was not related to bear abundance.

The authors suggest that compensation schemes, management practices, and human land use influence the number of claims for brown bear damage, while bear abundance does not. To be effective, the authors argue policies should be based on integrative schemes that prioritize damage prevention and make it a condition of payment of compensation that preventive measures are applied.

Bennett NJ, Roth R, Klain SC, Chan K, Christie P, Clark DA, Cullman G, Curran D, Durbin TJ, Epstein G, Greenberg A, Nelson MP, Sandlos J, Stedman R, Teel RL, Thomas R, Verissimo I, Wyborn C. 2016. Conservation Social Science: Understanding and Integrating Human Dimensions to Improve Conservation. *Biological Conservation* 205:93-108. DOI:10.1016/j.biocon.2016.10.0006.

Historically, the natural sciences have tended to be the sole or primary information source used to guide conservation action. Yet, many influential conservation scientists have long recognized the importance of both social and natural considerations for conservation. Social science research on conservation is increasingly commonplace as are commentaries on the need for more attention to the human dimensions of conservation. However, the integration of social science insights into conservation practice still remains limited and the field of conservation social science remains nascent.

Bennett et al. examine the scope and purpose of 18 subfields of classic, interdisciplinary, and applied conservation social sciences and articulate 10 distinct contributions that social sciences can make to understanding and improving conservation. They contend that the social sciences can help facilitate conservation policies, actions, and outcomes that are more legitimate, salient, robust, and effective.

Benson JF, Mahoney PJ, Vickers TW, Sikich JA, Beier P, Riley SPD, Ernest HB, Boyce WM. 2019. Extinction Vortex Dynamics of Top Predators Isolated by Urbanization. *Ecological Applications* 29(3):e01868. DOI:10.1002/eap.1868

Extinction risk is elevated in small, isolated populations due to demographic and genetic processes, but the relative influence of these processes is difficult to predict in different wildlife populations. Modeling dynamics of small, isolated populations can contribute to a better understanding of the forces driving extinction, as well as inform local conservation efforts.

Benson et al. conducted population variability analyses (PVA) for two mountain lion (*Puma concolor*) populations isolated by urbanization in southern California in order to predict population growth, extinction probability, and loss of genetic diversity. Based on predicted demographic processes over 50 years, the authors' modeling predicted 16-21% probability of local extinction for the isolated mountain lion population in the Santa Ana Mountains (SAM). Extinction risk for the SAM population was further exacerbated by inbreeding depression, suggesting that extinction is highly likely unless gene flow is increased. The Santa Monica Mountains (SMM) population had a slightly higher probability of extinction based purely on demographic processes, but increased immigration could largely mitigate the effects of isolation and reduce risk of extinction.

The greatest long-term threat to both populations appeared to be the rapid loss of genetic diversity associated with their geographic isolation. While mountain lions are not endangered in southern California, there is value to conserving viable populations of a native top predator within isolated mountain ranges to maintain naturally functioning ecosystems. Conservation of isolated populations will require habitat protection, mitigation of anthropogenic deterministic stressors, and the restoration of connectivity to ensure genetic diversity.

Benson JF, Sikich JA, Riley SPD. 2019. Survival and Competing Mortality Risks of Mountain Lions in a Major Metropolitan Area. *Biological Conservation.* In Press. DOI:10.1016/j.biocon.2019.108294

Understanding factors influencing survival and specific causes of mortality for top predator species is essential for conserving their populations. Large carnivores in human-dominated landscapes are especially sensitive to anthropogenic mortality, but detailed quantitative information on mortality patterns in urban areas is scarce. Benson, Sikich and Riley investigated mortality risk factors by radio-tracking 58 mountain lions (*Puma concolor*) in greater Los Angeles, California.

The risk from different causes of mortality significantly differed between age-classes, with sub-adult lions being more likely to die from intraspecific aggression by adult males, and adults more likely to die from human sources. The most frequent forms of human-caused mortality for mountain lions in the region included vehicle collisions and poisoning from rodenticides.

The higher morality from anthropogenic causes for adults, whose survival has the greatest influence on population growth and extinction probability for mountain lions—highlights the importance of mitigation strategies to reduce human-caused mortality, including targeted public education efforts, installing highway crossing structures, discouraging the use of rodenticides.

Bergstrom BJ. 2017. Carnivore Conservation: Shifting the Paradigm from Control to Coexistence. *Journal of Mammalogy* 98(1):1-6. DOI:10.1093/jmammal/gyw185.

A consensus is emerging among ecologists that extirpated, depleted, and destabilized populations of large predators are negatively affecting the biodiversity and resilience of ecosystems. Evidence assembled as of 2011 has led prominent ecologists to conclude that loss of apex predators was a major driver of destabilization and collapse of their native ecosystems (Estes et al 2011).

In this lead article of a thematic series on predator control, Bergstrom provides an overview of apex predators, wildlife management, and efficacy of lethal and nonlethal control methods. Bergstrom suggests that nonlethal methods of preventing depredation of livestock by large carnivores may be more effective; more defensible on ecological, legal, and wildlife-policy grounds; and more tolerated by society than lethal methods. Additionally, he argues that total mortality rates for a large carnivore may be driven higher than previously assumed by human causes that are often underestimated.

Bergstrom BJ, Arias LC, Davidson AD, Ferguson AW, Randa LA, Sheffield SR. 2013. License to Kill: Reforming Federal Wildlife Control to Restore Biodiversity and Ecosystem Function. *Conservation Letters* 7(2):131-42. DOI:10.1111/conl.12045.

Since 2000, the U.S. Department of Agriculture's Wildlife Services (WS) has killed 2 million native animals (WS 2012a), predominantly 20 species of carnivores, beavers, and several species of ground-dwelling squirrels, but also some non-target species. Many are important species in their native ecosystems (e.g. ecosystem engineers such as prairie dogs and beavers, and apex predators such as gray wolves).

Reducing these populations, locally or globally, risks cascading negative consequences including impoverishment of biodiversity, loss of resilience to biotic invasions, destabilization of populations at lower trophic levels, and loss of many ecosystem services that benefit human society directly or indirectly.

Lethal predator control is not effective at reducing depredation in the long term. Instead, Bergstrom et al. recommend that WS and its government partners involved in wildlife conflict management emphasize training livestock producers in methods of nonlethal control, with sparing use of lethal control by methods that are species-specific, and cease all lethal control in federal wilderness areas and for the purpose of enhancing populations of common game species.

Berkes F. 2004. Rethinking Community-Based Conservation. *Conservation Biology* 18(3):621–30. DOI:10.1111/j.1523-1739.2004.00077.x.

Conservation issues are complex systems-level problems; challenging because they cannot be disentangled from individual values, equity, and social justice—all of which are necessarily subjective. As such, many conservation problems do not actually lend themselves to the conventional, rational approach of data collection, analysis, and results-based decision making. There is too much uncertainty; targets keep shifting, and most issues must often be redefined. In that context, the most effective approaches will not be ordered along classic disciplinary lines. Rather, the issues will be addressed

simultaneously at multiple scales so as to reflect the fact that they are part of a complex social-ecological system.

Berkes offers a primer on the complexities entailed by community-based conservation. He discusses interdisciplinary conservation, adaptive co-management, local and traditional knowledge, incentivization, multiple stakeholders, scale and complexity, governance, and the relationship between community and institutions. He highlights the importance of addressing situation-specific complexities when undertaking any conservation activity, and suggests that a cross-scale approach to conservation alerts us to the notion that the scale at which we view a complex system affects what we see (i.e., what problems we orient toward). A cross-scale approach also helps address governance and community issues at multiple scales, depending on the conservation problem in question.

Berkes suggests that we shouldn't necessarily be asking *whether* community-based conservation works. Sometimes it does and sometimes it doesn't. It is more important to consider the conditions under which it does and does not work. He argues that it may ultimately be more productive to focus on institutions (defined broadly as the set of rules-in-use that structure human interaction), than on communities. Practically speaking, the challenge is often to strengthen institutions that may sustain conservation, while proactively negotiating around institutions that are ordered around other values.

Blackwell BF, DeVault TL, Fernandez-Juricic E, Gese EM, Gilbert-Norton L, Breck SW. 2016. No Single Solution: Application of Behavioural Principles in Mitigating Human-Wildlife Conflict. *Animal Behaviour* 120:245-54. DOI: 10.1016/j.anbehav.2016.07.013.

Human needs for space, shelter, and food will continue to ensure some degree of perceived 'trespass' when it comes to wildlife, a situation that paves the way for human-wildlife conflicts or HWC (Conover 2002). Nonlethal management approaches are critical to mitigating HWC (Shivik 2006), and more sustainable from ecological and social perspectives (Treves and Naughton-Treves 2005, Woodroffe et al 2005). Understanding the behavior of the target species is central to the efficiency and efficacy of nonlethal methods, although the role of behavior is sometimes not explicitly acknowledged in management policies or practices.

Blackwell et al. examined the theoretical and applied role that behavior plays in understanding and mitigating HWC, particularly as it related to larger and longer-term conservation efforts, and delineated gaps in behavioral theory relative to mitigating current HWC.

Focusing on animal-vehicle collisions and carnivore depredation of livestock, they found that only in the last decade have researchers applied antipredator theoretical framework with sensory ecology to understand aspects of responses to vehicle approach, speed, and associated stimuli. Within the context of carnivore-livestock depredation, managers need to better understand individual predator behavior relative to perceived risks in order to improve efficacy of the most promising nonlethal management approaches. In both cases, successful management is contingent upon a mechanistic understanding of how animals respond to disturbance and the information utilized to assess risk.

Blecha K, Boone R, Aldridge M. 2018. Hunger Mediates Apex Predator's Risk Avoidance Response in Wildland–Urban Interface. *Journal of Animal Ecology* 87:609-602. DOI:10.1111/1365-2656.12801.

Conflicts between large mammalian predators and humans present a challenge to conservation efforts, as these events drive human attitudes and policies concerning predator species. Unfortunately, generalities portrayed in many empirical carnivore landscape selection studies do not provide an explanation for a predator's occasional use of residential development preceding a carnivore–human conflict event.

Blecha et al. examined whether state-dependent mortality risk-sensitive foraging can explain an apex carnivore's (*Puma concolor*) occasional utilization of residential areas. The authors assessed whether puma balanced the risk and rewards in a system characterized by a gradient of housing densities ranging from wildland to suburban. Puma GPS location data, characterized as hunting and feeding locations, were used to assess landscape variables governing hunting site selection and success.

The authors found that residential development with high prey availability provided a high energetic reward to puma. Despite a higher energetic reward, hunting site selection analysis indicated that pumas generally avoided residential development, a landscape type attributed with higher puma mortality risk. However, when a puma experienced periods of extended hunger, risk avoidance behavior toward housing waned. Results demonstrate that an apex carnivore faces a trade-off between acquiring energetic rewards and avoiding risks associated with human housing. The authors suggest that periods of hunger can help explain an apex predator's occasional use of developed landscapes and thus the rare conflicts in the wildland–urban interface.

Boast L, Houser AM, Horgan J, Reeves H, Phale P, Klein R. 2016. Prey Preferences of Free-Ranging Cheetahs on Farmland: Scan Analysis Versus Farmer Perceptions. *African Journal of Ecology* 54:424-33. DOI: 10.1111/aje.12296.

The intensity of human-predator conflicts (HPC) is linked closely to farmers' attitudes and perceptions of predators. As a result, farmers' estimates of the number of livestock or game-stock animals killed by predators are often formed based on the perceived number of predators present and their perceivably favored prey species.

Boast et al. examined the prey preferences of cheetahs in relation to farmers' perceptions and the relative contribution of livestock and game-stock to the cheetahs' diet. Overall the authors found that cheetahs on Botswana's farmland predominantly pretty upon free-ranging wildlife species, despite an often greater abundance of livestock. Maintaining a diverse prey base is considered to be essential to reduce losses of predators (Marker-Kraus et al. 1996), and the number and associated costs of livestock losses are often greater in areas depleted of natural prey (Hemson 2003, Woodroffe et al. 2005).

However, on community lands in Botswana and across southern Africa, natural prey is thought to be declining due to land conversion to agriculture, habitat degradation and poaching (Mordi 1989, Moleele and Mainah 2003). Management options to promote veld management, and to diversify and improve rural livelihoods in order to discourage poaching could aid the recovery of natural prey populations, which is likely to reduce HPC. In addition, farmers' perceptions of the prey species consumed by

cheetahs were often incorrect; the authors suggest that conflict mitigation programs which emphasize and promote the importance of free-ranging prey in the cheetah's diet are likely to increase tolerance of predators.

Bogezi C, van Eeden LM, Wirsing A, Marzluff J. 2019. Predator-Friendly Beef Certification as an Economic Strategy to Promote Coexistence Between Ranchers and Wolves. *Frontiers in Ecology and Evolution*.7:476*.* DOI:10.3389/fevo.2019.00476

Market-based economic incentives are one avenue for promoting coexistence with carnivores. Meat products marketed as "predator-friendly" could reach consumers who are willing to pay for ecologically responsible ranch products that guarantee a producer did not use lethal predator controls. Bogezi et al. investigate various stakeholder perspectives on certification of predator-friendly beef as a market-based incentive to enable ranchers to better coexist with gray wolves (*Canis lupus*) in Washington State.

Through interviews and focus groups with stakeholders, Bogezi et al. identified some economic and social factors that might constrain or motivate ranchers to support a predator-friendly certification. Based on these responses, the authors propose a design for implementing a feasible predator-friendly beef market, and make the following recommendations: focus on the objectives of individual ranchers; ensure ranchers access to local beef processing facilities; develop a product brand favored by ranchers and beef processors; consider viable product pricing; and develop a regulatory process for qualifying producers as predator-friendly.

The authors conclude that predator-friendly certification presents an opportunity to promote coexistence between farmers and predators in Washington, especially if multiple stakeholders are consulted in the design process.

Bombieri G, Delgado M, Russo LF, Garrote PJ, López-Bao JV, Fedriani JM, Penteriani V. 2018. Patterns of Wild Carnivore Attacks on Humans in Urban Areas. *Scientific Reports* 8:17728. DOI:10.1038/s41598-018-36034-7

Attacks by wild carnivores on humans represent an increasing problem in urban areas across North America, and their frequency is expected to rise with increased urban expansion into carnivore habitats. Although these attacks are rare and generally result in minor injuries, they decrease public tolerance for these species and often result in lethal responses towards the animals considered responsible. Identifying the factors which may drive risky human-carnivore encounters in urban areas can contribute to our understanding of how best to coexist.

Bombieri et al. analyzed records of carnivore attacks on humans in urban areas of Canada and the U.S. between 1980 and 2016. The authors investigated the general patterns of the attacks, as well as the landscape structures and, for those attacks that occurred at night, the light conditions at the site. Their research found different trends for different carnivore species.

As different species attack under different conditions, Bombieri et al. concluded that management plans should be developed according to species occurring in a given area, avoiding generalizations. Furthermore, education actions should provide the public with practical information on how to avoid

conflicts and behave in an encounter, while landscape and urban planners should work to develop plans that balance human health, wildlife conservation, and conflict risk.

Bombieri G, Naves J, Penteriani V, Selva N, Fernández-Gil A, López-Bao JV, Ambarli H, Bautista C, Bespalova T, Bobrov V, Bolshakov V, Bondarchuk S, Camarra JJ, Chiriac S, Ciucci P, Dutsov A, Dykyy I, Fedriani JM. 2019. Brown Bear Attacks on Humans: A Worldwide Perspective. *Scientific Reports* 9:8573. DOI:10.1038/s41598-019-44341-w

Upward trends in large carnivore attacks on humans not only raise human safety concerns, but also may undermine conservation efforts by producing negative public opinions about large carnivores. Although rare, attacks by brown bears (*Ursus arctos*) are also on the rise and, although several studies have addressed this issue at local scales, information is lacking on a worldwide scale. In an effort to contribute to our knowledge on this type of conflict and provide useful information that could help reduce the occurrence of negative human-bear encounters, Bombieri et al. investigated patterns of brown bear attacks on humans occurring between 2000 and 2015 on a global scale.

The authors reviewed brown bear attack data and identified spatial and temporal patterns of incidents, compared attack circumstances, and considered the effect of various factors including population densities and management practices in different geographic locations. Of the 664 attacks that occurred, half of the people were engaged in leisure activities and the most prevalent scenario was an encounter with a female with cubs (47%). No significant difference was found in the number of attacks between countries with different management practices.

While negative encounters with brown bears are rare and mainly non-fatal, it is crucial to promote public knowledge of risky circumstances that may trigger an aggressive response by bears. Bombieri et al. urge researchers, managers, educators, and the media to provide correct and science-based information about bears to the public.

Bontrager A, Kretser H, Leong K, Connelly N. 2017. Conservation Opportunity and Risk Mapping for Carnivores Using Landowner Survey Data from the Greater Yellowstone Ecosystem. *Professional Geographer* 69(2):225-38. DOI:10.1080/00330124.2016.1208101

Comprehensive planning for wildlife corridors often requires passage over privately owned land. In the Rocky Mountain West, connectivity models often recommend corridors through exurban landscapes, a development pattern characterized by low-density residential parcels. The viability of wildlife travel corridors in privately owned landscapes depends in part on landowner attitudes towards conservation and various species.

Bontrager et al. used mail survey data from three communities in southwest Montana and Central Idaho to spatially assess carnivore occurrences, perceptions of carnivores, and landowner preferences toward conservation planning tools. The averages calculated for each of these three dimensions were used to map conservation opportunity and risk landscapes at a parcel level.

Conservation practitioners can use landowner data to determine which parcels require attention and what type of conservation strategy may be best suited based on specific landowners' attitudes and

experiences. The mapping of social data illustrates the importance of understanding individuals for conservation planning.

Bradley EH, Pletscher DH, Bangs EE, Kunkel KE, Smith DW, Mack CM, Meier TJ, Fontaine JA, Niemeyer CC, Jimenez MD. 2005. Evaluating Wolf Translocation as a Nonlethal Method to Reduce Livestock Conflicts in the Northwestern United States. *Conservation Biology* 19(5):1498-1508.

Translocation has been used for decades as a tool to mitigate livestock damage caused by bears, wild felids, and wolves. It helped further the Northern Rockies wolf recovery during its early phases by establishing new packs, as well as by augmenting existing packs in other areas, while removing depredating wolves from problematic locations.

Nonetheless, many translocated wolves die or disappear soon after release, without ever establishing a territory. Some others cause additional conflicts, resulting in their eventual lethal removal. Although most translocated wolves do not kill livestock after release, problems still often persist at the original conflict sites. As a result, translocated wolves that do prey on livestock in their new area contribute to higher net numbers of conflicts.

Bradley et al. examined the effectiveness of wolf translocation and found that translocation was most useful in the northern Rockies during early phases of wolf recovery, when encouraging establishment of new packs was a high priority and when there were ample suitable release sites.

Translocation has benefits and drawbacks. Now that wolf populations are larger, many of the benefits of translocation are reduced. Nonlethal efforts may be better focused on preventing and mitigating depredations at the original site of conflict, rather than simply moving or removing problem individuals. It is worth reiterating that conflict sites often persist beyond the removal of individual wolves, unless root causes are addressed. Preemptive conflict-mitigation efforts may prove useful to reduce conflicts as well as to help build a foundation for promoting coexistence within communities over the long term.

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(8):1337-46. DOI: 10.1002/jwmg.948.

Management methods used in Montana, Idaho, and Wyoming to mitigate wolf predation on livestock are highly controversial and heavily scrutinized, and their effectiveness is poorly understood. Wolf conflicts are managed primarily through lethal removal by agencies and public harvest to manage wolf numbers and distribution (USFWS et al. 2014); methods considered both necessary (Mech 1995) and controversial (Cluff and Murray 1995, Reiter et al. 1999, Bruskotter et al. 2009). Little was known, however, about the effects or removing depredating wolves on their packs' subsequent behavior.

Focusing on radio-collared packs in these three states, Bradley et al. examined data on livestock depredations and wolf removal conducted under authority of the USFWS and state agencies from 1989 to 2008. They examined the relative effects of three management responses—no removal, partial pack removal, and full pack removal—considering grazing seasons, livestock types, pack size, and removal of breeding individuals. They also analyzed depredation occurrence relative to increases in wolf population, and impact on wolf recovery overall.

Whereas previous large, regional-scale studies (Musiana et al. 2005, Harper et al. 2008, Wielgus and Peebles 2014) found no effect, or even a positive correlation between wolf removal and subsequent depredations, Bradley et al. found that scale matters. Their ability to examine individual packs and pack territories revealed that wolf removal did appear to reduce recurrence of depredations at the local level depending on the number of wolves remaining in the pack, and that depredation management is most appropriately studied at the wolf pack-level or local scale.

Brainerd SM, Andren H, Bangs EE, Bradley EH, Fontaine JA, Hall W, Iliopoulos Y, Jimenez MD, Jozwiak EA, Liberg O, Mack CM, Meier TJ, Niemeyer CC, Pedersen HC, Sand H, Schultz RN, Smith DW, Wabakken P, Wydeven AP. 2008. The Effects of Breeder Loss on Wolves. *Journal of Wildlife Management* 72(1):89-98. DOI:10.2193/2006-305.

Since wolves are highly social pack animals and each animal has a role in their community, the death of an individual can have varying significance depending on their status in the pack. Wolf managers periodically rely on the removal of depredating wolves, so it is important for managers to understand the effects of breeder loss on wolf social groups, relative to broader goals and strategies.

Brainerd et al. studied pack behavior in cases where one or both breeding members (alphas) were lost, tracking three key properties: pup survival, pack persistence, and the time to next breeding for persistent packs. The sex of a single surviving breeder was of little significance in determining whether a wolf pup in its pack would survive its first year. It was also relatively unimportant whether one or both breeders survived. Of more consequence was the total number of surviving adult wolves (whether breeders or auxiliary), because adults share responsibility for rearing the pups after weaning. They found that smaller packs showed a greater tendency to dissolve after breeder loss; dissolved packs disbanded into solitary adults who either joined neighboring packs or attempted to form their own; territorial wolves reestablished packs and recolonized the area in about half of the cases where observed packs dissolved; and neighboring packs occasionally expanded or shifted their territory to usurp the abandoned area.

The authors recommend that steps be taken to minimize the impact of breeder loss, which has a significant impact on the ability of a pack to persist and reproduce. Selective removal of pack members is difficult; thus, the authors argue that lethal control should be limited to solitary individuals or territorial pairs wherever possible. When reproductive packs must be managed, it is recommended that only those with pups greater than six months of age and greater than six pack members with at least three adult members be selected. This will maximize the odds that the pack persists. The authors also recommend that these packs should be close to neighboring packs and occur within larger (≥75) recolonizing populations.

Breck SW, Clark P, Howery L, Johnson D, Kluever BM, Smallidge S, Cibils AF. 2012. A Perspective on Livestock-Wolf Interactions on Western Rangelands. *Rangelands* 34(5):6-11. DOI:10.2111/RANGELANDS-D-11-00069.

Seeking to provide a science-based perspective to inform the ongoing wolf-livestock debate, Breck et al. conducted field and pen studies in Arizona to determine how predator (wolf and cougar) and non-predator presence or stimuli affect vigilance rates and foraging of cattle and wild ungulates. The authors

also conducted two studies on allotments in Idaho and eastern Oregon to evaluate effects of wolf presence on cattle habitat selection, terrain use, activity budgets, expression of predation-avoidance behavior, and productivity.

Results from the Arizona studies suggest several management implications to reduce the indirect effects of predation on cattle foraging behavior and to address animal distribution challenges. These include increased range riding and monitoring of mother cows during the calving season; synchronization of calving season to occur in locations with no or low wolf density; c) communication with wildlife biologists collared wolves' locations; and encouraging cattle forage in larger groups or in the same areas as wild ungulates.

The Northern Rockies studies suggest a need for more research due to the complexity of the ecological system and numerous interacting factors. The authors suggest producers consider carnivore presence when developing grazing plans and, overall, the need for a better understanding of wolf impacts on livestock in open grazing systems.

The authors suggest more intensive management of livestock combined with lethal and nonlethal wolf management strategies—multiple tools and techniques used in a context-dependent fashion and integrated into a science-based operation supported by producers

Breck SW, Kluever BM, Panasci M, Oakleaf J, Johnson T, Howery L, Bergman DL. 2011. Domestic Calf Mortality and Producer Detection Rates in the Mexican Wolf Recovery Area: Implications for Livestock Management and Carnivore Compensation Schemes. *Biological Conservation* 144:930-36. DOI:10.1016/j.biocon.2010.12.014.

Minimizing depredations and increasing tolerance by livestock producers is critical for conservation efforts. Breck et al. investigated factors influencing calf mortality and producer detection rates at two sites in the Mexican wolf recovery area. Study areas differed in grazing practices, density of predators, and amount of effort spent monitoring cattle.

Calves selected by predators were on average 25 days younger than the surviving cohort. Year-round calving is practiced in these study areas. Results indicate that year-round calving, especially in areas with high predator densities, leads to higher losses primarily because vulnerable calves are exposed to mortality agents for a higher proportion of time.

Breck et al. suggest these results support changing husbandry practices to limit calving to a seasonal endeavor. In a broader sense, it highlights the importance of monitoring livestock and targeting the timing and location of calving/lambing so as to minimize exposure to predators.

Widely disparate mortality detection rates across these study sites highlight the significance of producer effort in finding and verifying depredations. Breck et al. suggest that compensation programs—utilized to mitigate the economic effects of carnivores—should focus on performance-payment schemes where payment is based on conservation outcomes (e.g., carnivore offspring) and compensation is based on damage that animals are expected to cause (rather than inconsistent and difficult to verify ex-post claims).

Browne-Nunez C, Treves A, MacFarland D, Voyles Z, Turnig C. 2015. Tolerance of Wolves in Wisconsin: A Mixed Methods Examination of Policy Effects on Attitudes and Behavioral Inclinations. *Biological Conservation* 189:59-71. DOI:10.1016/j.biocon.2014.12.016.

Understanding attitudes toward wolves and wolf management is important because they can predict how people may behave toward wolves and respond to wolf management actions (Bruskotter et al. 2009). Monitoring change in attitudes over time is of particular relevance in wolf management given the high level of polarization and continuously evolving management landscape. For instance, numerous studies have shown that majorities of survey respondents held positive views of wolves, but a 2001-2009 panel study found declining tolerance for wolves among residents of Wisconsin's wolf range.

Browne-Nunez et al. conducted focus groups and anonymous questionnaire surveys among hunters and farmers in Wisconsin's wolf range to gain a more in-depth understanding of attitudes toward wolves and inclination to poach wolves. The authors convened focus groups before and after Wisconsin implemented lethal-depredation control and created the state's first legalized wolf-harvest season in 2012.

Their results showed majorities of respondents held negative attitudes toward wolves with no decrease in inclination to poach, suggesting lethal-control measures, in the short term, may be ineffective for increasing tolerance. Participants expressed favorable attitudes toward lethal-control measures, but believed there were limitations in their implementation. Focus group discussions revealed elements of positivity toward wolves not revealed by questionnaires, as well as several thematic areas—fear, empowerment, trust—that may inform in the development of interventions designed to increase tolerance of wolves and other controversial species.

Participants did express appreciation for being asked for input; feelings of powerlessness were in part the result of perceived dominance of outside groups in affecting state/local policy. The authors support the use of a mixed-methods approach when exploring sensitive human-wildlife topics, and encourage participatory research methods in order to empower individuals and groups. These may offer managers the opportunity to not only increase perceived and actual stakeholder empowerment, but also increase trust by increasing avenues of communication between agencies and constituents.

Bruskotter JT, Enzler SA, Treves A. 2011. Rescuing Wolves from Politics: Wildlife as a Public Trust Resource. *Science* 333(6051):1828-29. DOI:10.1126/science.1207803.

In the absence of Endangered Species Act protection, wolf management reverts to the states. Will states honor the substantial public investment made in wolf restoration or seek to dramatically reduce or even eliminate wolf populations? The answer may depend on how states interpret a legal doctrine with roots dating back to ancient Roman and English common law.

Bruskotter et al. explore the history and intent of the public and wildlife trust doctrines, state wildlife powers, and the need to develop case law necessary for broader judicial application of the wildlife trust. The authors argue that without judicial application of an enforceable obligation, the fate of wolves, and many other imperiled species, remains uncertain.

Bruskotter JT, Fulton DC. 2012. Will Hunters Steward Wolves? A Comment on Treves and Martin. *Society and Natural Resources* 25(97-102). DOI:10.1080/08941920.2011.622735.

As wolf conservation transitions away from federally sponsored protection and recovery toward sustainable management under state fish and game agencies, researchers, and policymakers are interested to know what role hunters will play. Based upon hunters' responses to three recent surveys in Wisconsin and the northern Rockies, Treves and Martin (2011) question the assumption that hunters will steward wolves, noting that the majority of hunters that responded were unsupportive of wolf conservation. However, this conclusion largely depends upon what is meant by stewardship and what actions are required for wolves to be conserved.

Bruskotter and Fulton explored three concepts explicitly or implicitly discussed by Treves and Martin—tolerance, acceptance, and stewardship—and offer a conceptual model of wildlife conservation behavior that they argue clarifies the relationship among these concepts.

They note that the U.S. Fish and Wildlife Service delisted wolves under the assumption that state management would build tolerance for the species (Bruskotter et al. 2010). This is but one of many untested assumptions regarding how to go about mitigating the threat posed by human beings—the only legitimate threat to wolves in the lower 48 states (Bruskotter et al. 2010, Smith et la. 2010).

Bruskotter JT, Toman E, Enzler SA, Schmidt RH. 2010. Are Gray Wolves Endangered in the Northern Rocky Mountains? A Role for Social Science in Listing Determinations. *BioScience* 60(11):941-948.

The question of how to manage wolves in the Northern Rockies transcends the biological and ecological sciences. Wolf management efforts underscore how intricately human behaviors are linked with the long-term success of the species. Of 2094 wolf mortalities documented by the US Fish & Wildlife Service between 2000 and 2009, 84% were human caused, and at least 80% of these were intentional control actions or harvest. Within that context, it has frequently been observed that wolf recovery issues have more to do with personal values than with wolves themselves.

This does not diminish the importance of biophysical-ecological data in management. It suggests, however, that the social sciences can also provide valuable information that should be considered in decisions such as listing determinations. Despite lip-service to the contrary, social sciences are not integrated sufficiently into controversial conservation actions (even those pertaining to species like wolves that have long-recognized human connections).

Bruskotter et al. suggest that management agencies have historically failed to sufficiently address social factors in their management decisions. They argue that when agency decisions turn on assumptions about society, agencies should employ appropriate social science methodologies to explicitly evaluate those assumptions in order to improve policy and management decisions.

Bruskotter J, Vaske J, Schmidt R. 2009. Social and Cognitive Determinants of Utah Residents' Acceptance of the Lethal Control of Wolves. *Human Dimensions of Wildlife* 14:1-14. DOI:10.1080/10871200802712571.

Public acceptance of wildlife-related policies and actions is critical to successful implementation of

management and the conservation of a species. It has been found that lethal control of species, particularly charismatic mega-fauna such as bears, wolves, and deer, is highly controversial.

State and federal agencies must determine which methods of control are acceptable for species likely to cause controversy and identify factors that affect the acceptability of lethal control. Bruskotter et al. used a mail-in study from 709 Utah Residents to: (1) describe the acceptability of various means of controlling wolves that prey on livestock; (2) examine factors associated with the acceptability of lethal control; and (3), develop a model predicting the acceptability of lethal control.

The study showed that three factors—cognitive, social, contextual—can be related to the acceptability of wildlife management actions. Bruskotter et al. found that acceptability of lethal controls varied among the stakeholder groups, but there was no variation among stakeholder opinions regarding nonlethal methods suggesting that nonlethal methods are less controversial.

The authors note that variations linked to lethal controls were reduced when beliefs about wolf impacts and attitudes toward wolves were controlled; these two factors explained 42% of the acceptability variance. They suggest that effects of stakeholder identification on acceptability of lethal control are influenced by cognitive factors.

Bruskotter JT, Vucetich JA, Manfredo MJ, Karns GR, Wolf C, Ard K, Carter NH, López-Bao JV, Chapron G, Gehrt S, Ripple WJ. 2017. Modernization, Risks, and Conservation of the World's Largest Carnivores. *BioScience* 67(7):646-55. DOI:10.1093/biosci/bix049

Recent advances in carnivore conservation in portions of Europe and North America illustrate that human populations can coexist with these species, at least under certain conditions. Bruskotter et al. contend that conservation outcomes are improved when social and economic forces reduce risks associated with carnivores.

The authors discuss how social and ecological changes might affect the conservation of carnivores with a focus on modernization (i.e., a suite of social changes, including occupational specialization, rising educational levels, and rising wealth that accompany industrialization). They also present three propositions: 1) Societal tolerance for carnivores is affected by the distribution of risks and benefits associated with these species; 2) modernization and its associated social changes reduce the risks associate with large carnivores and their conservation; and 3) modernization induces lasting effects on conservation by changing societal values.

Although human activities are almost universally perceived as negatively affecting carnivore conservation, Bruskotter et al. point to worldwide patterns in the conservation status of carnivores that may suggest that certain elements of modernization may facilitate carnivore conservation.

Caroll C, Parks S, Dobrowski S, Roberts D. 2018. Climatic, Topographic, and Anthropogenic Factors Determine Connectivity Between Current and Future Climate Analogs in North America. *Global Change Biology* 24:5318–31. DOI:10.1111/gcb.14373

As climatic conditions shift in coming decades, persistence of many populations will depend on their ability to colonize habitat newly suitable for their climatic requirements. Due to wolves, bears, and

mountain lions' need for large ranges necessary for life history developments, these species are prone to the cascading ecological effects of climate change and habitat conversion. Opportunities for range shifts may be limited unless areas that facilitate dispersal under climate change are identified and protected from land uses that impede species migration and movement (Mora et al. 2013).

Carroll et al. modeled and identified climate connectivity areas across North America by delineating paths of wildlife migration between current climate types and their future analogs. Paths were funneled along north-south trending passes and valley systems and away from areas of novel and disappearing climates. The authors then identified priority areas for connectivity under climate change by connecting regions with similar current and future climate analogues while minimizing overlap with differing climate analogues.

Models demonstrated that current protected areas missed areas of modeled connectivity refugia leaving them prone to anthropogenic land use and habitat conversion. Priority regions of connectivity lacking protected areas in Alaska, New Mexico, and British Columbia, threaten the permeability and movement of large carnivores, limiting their adaptive capacities in the face of climate change.

Carroll C, Rohlf DJ, Li Y-W, Phillips MK, Noss RF. 2014. Connectivity Conservation and Endangered Species Recovery: A Study in the Challenges of Defining Conservation-Reliant Species. *Conservation Letters* 8(2):132-38. DOI:10.1111/conl.12102.

Listing of species under the US Endangered Species Act (ESA) is designed to trigger an array of federal regulatory provisions that protect both the species and its habitat in order to allow a species' status to improve to the point at which the measures provided pursuant to the ESA are no longer necessary. Some of the earliest species delisted were threatened by things that could be comprehensively addressed by federal regulations.

In contrast, many currently listed species face ecologically complex threats that are less amenable to regulation remedy (Doremus and Pagel 2001). Many species have experienced a reduction in population connectivity (Soule and Terborgh 1999), which may impact demographic and genetic flows that support persistence of peripheral populations and long-term maintenance of a species' evolutionary potential (Lowe and Allendorf 2010).

Carroll et al. reviewed the limited guidance provided by the ESA and subsequent case law related to what level of connectivity restoration is appropriate before a species is delisted. They then considered examples from a range of listed species to discover commonalities that can clarify key questions regarding connectivity restoration for endangered species.

Carroll et al. found that for species facing long-term threats from invasive species or climate change, restoration of natural dispersal may not be technically feasible in the foreseeable future. For other species, restoration of natural dispersal is feasible, but carries economic and political cost. They argue that distinguishing between these two groups better informs policy by distinguishing the technical challenges posed by novel ecological stressors and the degree to which we should grow accustomed to direct human intervention in species' lifecycles as a component of conservation.

Carter NH, Linnell JDC. 2016. Co-Adaptation is Key to Coexisting with Large Carnivores. *Trends in Ecology and Evolution* 31(8):575-78. DOI:10.1016/j.tree.2016.05.006.

Protected areas are crucial for large carnivore conservation. However, the vast ranges required by these animals mean that co-occurrence with humans is, and has been, common in shared landscapes outside protected areas. Given that shared landscapes often represent a vital part of their remaining geographic distribution, eradication of large carnivores from these areas threatens their conservation. Operationalizing human-carnivore coexistence in these areas is essential to global carnivore recovery efforts and maintaining (or improving) human wellbeing (Ripple et al. 2014, Chapron et al. 2014, Carter et al. 2014), but an unclear, inconsistent, or naïve conceptualization of coexistence hinders the ability of opposing stakeholders to implement coexistence strategies.

Carter and Linnell articulated a coexistence definition that focused on mutual adaptation on the part of both humans and carnivores, including human-carnivore and human-human interactions, that can help unify disparate interpretations of coexistence so that human and natural systems are fundamentally integrated. They suggest that their concept of coexistence can be a starting point from which to advance both the interdisciplinary theory and practice of coexistence.

Chamberlain E, Rutherford M, Gibeau M. 2012. Human Perspectives and Conservation of Grizzly Bears in Banff National Park, Canada. *Conservation Biology* 26:420–31. DOI:10.1111/j.1523-1739.2012. 01856.x.

Conservation initiatives have the potential to stir up intense conflict among stakeholders due to conflicting views on conservation problems and solutions. Tools are needed to depolarize such situations, help foster understanding of the perspectives of people involved, and find common ground.

Chamberlain et al. studied the perspectives of stakeholders (local residents, scientists, agency personnel, and representatives from NGOs and other interest groups) on conservation and management of grizzly bears in Banff National Park and the Bow River watershed of Alberta, Canada. The authors found that individuals from different groups held different views about grizzly bears, parks, and humans in the Banff-Bow Valley as well as different definitions of the problem of grizzly bear management. Furthermore, they established clear links between the way participants defined the problem and the solutions they preferred.

The results were used to inform a series of workshops in which stakeholders developed and agreed on new management strategies that were implemented by Parks Canada. The study is important in determining motives and values in various individuals, and finding common ground between stakeholders in order to develop proactive management strategies.

Chapron G, Treves A. 2016. Blood Does not Buy Goodwill: Allowing Culling Increases Poaching of a Large Carnivore. *Proc Royal Society B* 283(1830):20152939. DOI:10.1098/rspb.2015.2939

Evaluating the effectiveness of interventions aimed at abating environmental crimes such as illegal hunting and poaching has become fundamental to conservation policy making. However, while identifying the causes and extent of mortality is a central line of inquiry in biology and ecology, it remains notoriously difficult for poaching because evidence is typically concealed from enforcement

agencies and scientists alike. As a consequence, illegal hunting or poaching has become a major concern for conservation of endangered species, particularly for controversial species such as large carnivores.

Chapron and Treves conducted a quantitative evaluation of the hypothesis that liberalizing culling will reduce poaching and improve population status of the endangered gray wolf. Employing a population-policy model, results indicate that wolf culling was substantially more likely to increase poaching than reduce it. Furthermore, replicated quasi-experimental changes in wolf policies in Wisconsin and Michigan revealed that policy signals to allow culling triggered repeated slowdowns in wolf population growth, irrespective of the policy implementation measured as the number of wolves killed.

The authors determined that the most likely explanation for these slowdowns was poaching, while alternative explanations found no support. They suggest that when the government kills a protected species, the perceived value of each individual of that species declines resulting in negative message about the value of wolves or acceptability of poaching. As a result, the perception of a policy may be as important to understand carefully as are the enforcement and compliance checks that represent implementation.

Clark DA, Slocombe DS. 2011. Adaptive Co-Management and Grizzly Bear-Human Conflicts in Two Northern Canadian Aboriginal Communities. *Human Ecology* 39:627-40. DOI:10.1007/s10745-011-9423-x.

For remote communities, horizontal and vertical institutional connections are important for facilitating learning and the integration of information in wildlife management. Clark and Slocombe examined two case-studies of human-grizzly bear conflict in northern Canada, inquiring into whether management crises can drive the emergence of adaptive co-management. In both cases, grizzly bear-human conflicts acted as focusing events that in some ways engendered comparable responses. Nonetheless, the specifics of each context entailed different functional outcomes.

In both cases, existing institutions deliberately investigated local knowledge to inform future decisions about wildlife conflicts. In one case, existing institutions coped with the conflicts more-or-less successfully, without having to be modified (the bear-human system buffered the changes without having to change its structure). In the other case, bear-human conflicts pushed the system into reorganization and prompted community-level participants to undertake a transformation of the management/decision-making system. This case was characterized by very few vertical and no formal horizontal connections among governance institutions, giving it unwieldy rigidity when it was felt that management regimes needed to evolve.

Both cases exhibit most of the conditions that are generally agreed to be necessary for successful adaptive co-management. The most apparent explanatory difference probably lies in the policy environment for local collaborative management efforts. Though both cases have mandates for co-management, they functionally vary in terms of the richness and density of interconnection across different institutional scales.

Clark and Slocombe suggest that the emergence of adaptive co-management may require a hospitable niche in time, space, and society that is likely to be a narrow one. Cross-scale institutional communication and venues for collaborative learning seem to be critical for positive outcomes. The

authors observe that cross-scale communication is necessary for institutional learning and adaptation to change.

Clark DA, Slocombe DS. 2011. Grizzly Bear Conservation in the Foothills Model Forest: Appraisal of a Collaborative Ecosystem Management Effort. *Policy Sciences* 44:1-11. DOI:0.1007/s11077-010-9118-y.

Ecosystem approaches to conservation have been promoted for large carnivores worldwide. Nonetheless, carnivore conservation depends on more than understanding the species' biological needs. Societal values, narratives, and the institutions that give them expression are now recognized as critical determinants of bear survival—not least because of strong symbolism(s) attached to grizzlies. To date, many ecosystem management efforts have not attended sufficiently to these human dimensions.

Clark and Slocombe examined the development and eventual termination of a collaborative grizzly bear conservation program in the Foothills Model Forest (FMF), in west-central Alberta. The regional ecosystem approach for conserving grizzlies in the FMF originated in the federal and provincial legislative processes, but proved vulnerable to shifting goals and containment by a single powerful participant. It operated on open consensus and shared decision-making principles, but was effectively terminated prior to the implementation of any of its findings or recommendations; an outcome perceived by some stakeholders as the result of a goal shift and containment strategy originating from one particular group of participants.

Clark and Slocombe suggest tenuous prospects for grizzlies will probably not improve without fundamental improvements in governance. The ecosystem approach implemented in the FMF was evidently vulnerable to manipulation. It was simply not sustainable despite its origins in federal and provincial legislation: administrative changes by one participant (namely the Alberta government) were sufficient to terminate it. To enable success of other such conservation efforts, Clark and Slocombe recommend supporting emergent small-scale initiatives, designing collaborative institutions that limit the potential for containment of decision processes.

Coleman TH, Schwartz CC, Gunther KA, Creel S. 2013. Grizzly Bear and Human Interaction in Yellowstone National Park: An Evaluation of Bear Management Areas. *Journal of Wildlife Management* 77(7):1311-20. DOI:10.1002/jwmg.602.

Wildlife managers often rely on permanent or temporary area closures to reduce the impact of human presence on sensitive species. In 1982, Yellowstone National Park created a program to protect threatened grizzly bears from human disturbance. The bear management area (BMA) program created areas where human access was restricted. The program was designed to allow unhindered foraging opportunities for bears, decrease the risk of habituation, and provide safety for backcountry users.

Coleman et al. evaluated human-bear interaction in BMAs to determine if the restricted areas were effective. They used human and grizzly bear global positioning system location data to study 6 BMAs from 2007 to 2009, contrasting data when BMAs were unrestricted (open human access) and restricted (limited human access).

Coleman et al. found that grizzly bears were twice as likely to be within a human recreation area (HRA) when BMAs were restricted, and that grizzly bears were more than twice as likely to be within an HRA

when BMAs were unrestricted but people were inactive. They suggest that human presence can displace grizzly bears if people are allowed unrestricted access to the 6 BMAs studied, and that the results provide evidence for utility of management closures designed to protect a threatened species in a well-visited park.

Coogan SCP, Coops NC, Janz DM, Cattet MRL, Kearney SP, Stenhouse GB, Nielsen SE. 2019. Towards Grizzly Bear Population Recovery in a Modern Landscape. *Journal of Applied Ecology* 56:93-9. DOI:10.1111/1365-2664.13259

Coogan et al. consider what they describe as a dichotomy in social responses to scientific news stories regarding grizzly bears (*Ursus arctos*). While there appears to be strong positive support for research highlighting conservation challenges, there is also skepticism and even outright denial as to the quality of scientific knowledge related to more "unpopular" conservation issues, such as delisting and trophy hunting. In some cases, social and political opinions are the deciding factors in public policy decisions over science-based evidence.

The authors use grizzly management in Alberta, Canada as a test case for implementing an interdisciplinary and collaborative approach to monitoring bear populations in a landscape used by multiple stakeholders. They describe the complex and multidimensional factors acting upon grizzlies that necessitate monitoring and assessment, including wildlife health, population dynamics, stress, and international challenges.

According to the authors, the data and subsequent insight acquired from an interdisciplinary and multi-scalar scientific approach to population recovery and management may ultimately contribute towards improving public faith in the scientific process informing decision making. Public understanding and acceptance of science-based research is necessary for carnivore conservation, especially if societal values and ethics ultimately shape management policies.

Costello CM, van Manen FT, Haroldson MA, Ebinger MR, Cain SL, Gunther KA, Bjornlie DD. 2014. Influence of Whitebark Pine Decline on Fall Habitat Use and Movements of Grizzly Bears in the Greater Yellowstone Ecosystem. *Ecology and Evolution* 4(10):2004-18. DOI:10.1002/ece3.1082.

When abundant, seeds of the high-elevation whitebark pine are an important fall food for grizzly bears in the Greater Yellowstone Ecosystem. Rates of bear mortality and bear/human conflicts have been inversely associated with WBP productivity. Recently, mountain pine beetles have killed many cone-producing WBP trees. Costello et al. used fall Global Positioning System locations from 89 bear years to investigate temporal changes in habitat use and movements during 2000–2011.

One-third of sampled grizzly bears had fall ranges with little or no mapped WBP habitat. Most other bears appeared to select for WBP habitats. The authors detected no trends in movement indices over time. Outside of national parks, there was no correlation between the MC indices for WBP habitat and secure habitat, and most bears selected for secure habitat. Nonetheless, mean MC index for secure habitat decreased over the study period during years of good WBP productivity.

The wide diet breadth and foraging plasticity of grizzly bears likely allowed them to adjust to declining WBP. Bears reduced use of WBP stands without increasing movement rates, suggesting they obtained

alternative fall foods within their local surroundings. However, the reduction in mortality risk historically associated with use of secure, high-elevation WBP habitat may be diminishing for bears residing in multiple-use areas.

Crook SES. 2014. Information Spread in a Region of Human-Mountain Lion Coexistence. *Human Dimensions of Wildlife* 19(6):555-58. DOI:10.1080/10871209.2014.918220.

The media has a significant role in spreading information about human-wildlife conflict, but they are just one of a number of sources from which the public garners knowledge. Knowing the sources of public knowledge can provide managers and researchers insight into how attitudes, knowledge, and risk perceptions are formed, and how to prioritize and structure education and outreach to achieve management goals.

Using a convenience sampling approach focused on attitudes about mountain lions, Crook surveyed adult residents living in and around the Santa Cruz Mountains—home to an estimated 70 mountain lions—asking them about their experiences with the animals, their sources for information, and their frequency of information exposure.

The survey results demonstrated that the majority of respondents had experience with mountain lions and received information about mountain lion issues from friends and neighbors nearly as frequently as from media sources.

Few respondents reported hearing about mountain lions directly from officials or scientists, and analysis of relevant articles found in the local newspaper, cited other citizens more often than members of government agencies.

Crook suggests that government officials, scientists, and NGOs may consider prioritizing influence building through outreach campaigns in addition to increasing their presence in the media. However, he noted that given the convenience sampling approach was adopted for his study, caution should be exercised in generalizing study findings to the entire population.

Decesare N, Wilson S, Bradley E, Gude J, Inman R, Lance N, Laudon K, Nelson A, Ross M, Smucker T. 2018. Wolf-Livestock Conflict and the Effects of Wolf Management. *Journal of Wildlife Management* 82(4):711-22. DOI:10.1002/jwmg.21419

Wolf depredations of livestock are a ubiquitous source of conflict in every country where wolves and livestock overlap. Understanding the spatial and temporal variations of livestock depredation by wolves assists managers and landowners with mitigating conflicts and employing best practices

DeCesare et al. collected spatial data for all confirmed wolf-livestock depredations in Montana from 2005-2015, tallying the annual depredation events within hunting districts, and collected data for variables potentially predictive of depredation events. The authors found that depredation events increased with wolf density and livestock density, while finding that districts with depredations the previous year were more likely to continue experiencing them. Concurrently, the authors found no evidence that removing wolves through public harvest affected the year-to-year presence or absence of livestock depredations.

While the strongest predictor of wolf-livestock depredation was the occurrence of depredation in the previous year, the authors recommend an equal split between preventative efforts to reduce depredations where conflict is less common and reactive and lethal efforts to reduce the severity or number of conflicts in places where they are more common.

Decker D, Jacobson C, Brown T. 2006. Situation-Specific "Impact Dependency" as a Determinant of Management Acceptability: Insights from Wolf and Grizzly Bear Management in Alaska. *Wildlife Society Bulletin* 34(2):426-32

Decker et al. explored the way in which peoples' opinion of lethal control depends on situation-specific context. They addressed whether the perceived impacts of wildlife on humans make a difference in whether individuals tend to support (or oppose) lethal management actions.

Study respondents were more likely to support lethal methods to control wolf and bear predation on trophy game animals (moose and caribou). Conversely, lethal control of predator populations was less likely to be supported in situations where the impact of predators on game populations was perceived to be less severe (with respect to human needs).

The authors describe this relationship as 'impact dependency,' and suggest that it is important to consider context-specific influences on public evaluations of management actions. Although they stress the importance of other characteristics of management interventions (e.g., relative humaneness, cost, efficiency, etc.), the authors suggest that managers should consider how public support for a particular action is influenced by public perceptions—particularly relating to the nature of how the situation is impacting people.

Dickman AJ. 2010. Complexities of Conflict: The Importance of Considering Social Factors for Effectively Resolving Human-Wildlife Conflict. *Animal Conservation* 13:458-66. DOI:10.1111/j.1469-1795.2010.00368.x

How people perceive and react to risks is heavily influenced by social-cultural perceptions and values, particularly in regard to ideas of what the world *should* be like. For example, orientation to whether wild carnivores *should* be part of a natural landscape affects perceptions of reasonable risk. Issues of social and economic stability/security may also heighten sensitivities to perceived risks. The landowner at the mercy of weather, commodity markets, and regulations imposed by outsiders, may be particularly sensitive to the introduction of another uncontrolled variable like wolves. Such a variable—which the landowner *can* exert some direct control over or kill—can be an easy target for the expression of feelings about even broader issues.

Conflict mitigation efforts often fail because conservation biologists make broad assumptions about human attitudes and behavior that do not match the realities of the situation. Dickman points out that human-wildlife conflicts are often shaped and driven by complex social factors. Moreover, he argues, they often invoke underlying human-human conflicts (i.e., between authorities/government and local people, or between people of different cultural backgrounds).

Dickman tabulates a number of conflict mitigation approaches and recommends that conservation biologists examine their local situations in-depth and carefully consider what factors are influencing conflict, before deciding which mitigation strategies are likely to be most successful. Reducing wildlife damage alone will often fail to produce long-term conflict resolution. It is vital for conflict professionals to consider the assumptions they are working under, and test their veracity in the site concerned. Dickman notes that it is important to be aware of when, where, and how different conflict mitigation strategies may (or may not) produce real conservation benefits.

Dickman AJ, Macdonald EA, Macdonald DW. 2011. A Review of Financial Instruments to Pay for Predator Conservation and Encourage Human-Carnivore Coexistence. *Proc Natl Acad Sci* 108(34):13937-944. DOI:10.1073/pnas.1012972108

Conservationists are challenged to facilitate protection of species that may be highly valued at a large (even global) scale, but have little or even negative value at a local scale. Costs and benefits involved in predator conservation often include diverse dimensions, which are hard to quantify and nearly impossible to reconcile with one another. Although human-carnivore conflict involves significant non-economic values, providing financial incentives to those affected negatively by carnivore presence is a common strategy for encouraging coexistence.

Some compensation schemes take an ex-post approach, compensating costs as they are imposed by carnivores (i.e., depredation compensation programs). Other ex-ante programs provide payments based on the assumption that carnivores will impose some general level of cost. Dickman et al. review such financial instruments, and assess the pitfalls and potentials of these methods, particularly compensation and insurance, revenue sharing, and conservation payments.

The authors argue that determining the correct level of payments is critically important: payments must be sufficient to outweigh costs imposed to the payee, but also in proportion to the actual direct ecological benefits derived and the benefits produced for the larger stakeholder community. It is important to assess whether the threats to the carnivore population in question are actually likely to be mitigated by the program, and whether the program can be implemented at a scale likely to secure the target population.

Citing the privately funded Defenders of Wildlife compensation program in the Northern U.S. Rockies, and the Swedish government payments to Sami herders to conserve lynx and wolverine, the authors argue that conservation payments can be a beneficial tool. Any scheme needs to be tailored carefully to the individual situation to avoid problems of perverse incentives, additionality, and leakage; to ensure that the desired conservation outcomes are achieved; and to satisfy the economic and cultural needs of people bearing the costs associated with living with wildlife.

Dickman AJ, Marchini S, Manfredo M. 2013. The Human Dimension in Addressing Conflict with Large Carnivores. *Key Topics in Conservation Biology*, Vol 2. Wiley-Blackwell. DOI:10.1002/9781118520178.ch7

Maintaining viable populations across many large carnivores' ranges depends upon developing effective conservation strategies on human-dominated land. However, achieving harmonious human-carnivore coexistence is problematic as these species can impose significant costs on local communities, mainly

through livestock depredation. As a result, communities worldwide resort to reactionary killing of carnivores, threatening their conservation.

Dickman et al. highlight the pressing need to develop effective conflict mitigation strategies rooted in social science to preserve carnivore populations and protect affected livelihoods.

Presented as an analysis of global perspectives and literature highlighting the human dimensions of carnivore conflict, the authors conclude that attitudes toward carnivores are not merely determined by any direct costs imposed but are the product of a dynamic and complex web of individual, societal, and cultural factors. As a result, the authors propose that reactionary carnivore killing results from the interplay between individual influences and social and cultural motivations. They argue that effective strategies for preventing killing must be based on these characteristics as well as on economic and legal considerations of communities. The authors conclude by making a broad appeal for conservationists to be aware of the complex, dynamic nature of carnivore conflicts, and develop solutions that are not externally imposed but which are locally driven, participatory, and culturally sensitive, in order to make carnivore killing personally, socially, and culturally unacceptable.

Dietsch AM, Teel TL, Manfredo MJ. 2016. Social Values and Biodiversity Conservation in a Dynamic World. *Conservation Biology* 30(6):1212-21. DOI:10.1111/cobi.12742.

People seeking to address contemporary conservation challenges by fostering pro-conservation behaviors have increasingly turned to research investigating the basis of human thought and action (Mascia et al. 2003, Schultz 2011, Bennett and Roth 2015). Understanding what shapes values, which ultimately shape human behavior, can help improve the effectiveness of conservation solutions that depend on public support.

Dietsch et al. investigated the influence of societal-level changes, such as modernization, on values in a multilevel framework, and then explored how values influence conservation support at different levels (e.g., individual and county). They found positive associations between county-level examples of modernization and mutualism, and negative associations between modernization and domination, independent of a respondent's socio-demographics.

Their findings are consistent with previous research describing how modernization as a broad social phenomenon influences values (Inglehart and Welzel 2005, Schwartz 2006), and how value shift has affected the way humans think about and interact with their surroundings, including wildlife (Manfredo et al. 2009).

Dilkina B, Houtman R, Gomes CP, Montgomery CA, McKelvey KS, Kendall K, Graves TA, Bernstein R, Schwartz MK. 2016. Trade-offs and Efficiencies in Optimal Budget-Constrained Multispecies Corridor Networks. *Conservation Biology* 00(0):1-11. DOI:10.0000/cobi.12814.

Under the pressures of rapid human development and climate change, wildlife habitat has been diminished and fragmented, which at times compromises the ability of many species to persist (Hanski and Ovaskainen 2000, Fahrig 2003, Haddad et al. 2015). Faced with these trends, conservation biologists have pushed for creation of systems of protected areas (Hole et al. 2009), which has resulted in

extensive research and development of methods that inform reserve design (Sarkar et al. 2006, Moilanen et al. 2009).

Biologists and ecologists recognize that a simple system of protected areas, serving as isolated safe havens for biodiversity, will not be sufficient for long-term biodiversity maintenance. Thus, preserving and restoring habitat connectivity is a key conservation priority for government agencies and conservation organizations (Crooks and Sanjayan 2006, Beier et al. 2011, Haddad et al. 2015), and is increasingly considered in conservation methodologies (Beier et al. 2008, Lentini et al. 2013).

Several recent studies show that to design efficient, practical conservation strategies, it is crucial to incorporate economic, ecological, and biodiversity considerations from the outset. Dilkina et al. devised an optimization framework for a budget-constrained corridor design problem that simultaneously incorporates spatially explicit models of species-specific resistances and spatially heterogeneous economic costs of conservation actions; they applied it to a case study of corridor design for wolverines and grizzly bears in western Montana.

Dilkina et al. found that designing corridors for single species based on purely ecological criteria can lead to expensive linkages that are suboptimal for multispecies connectivity objectives. Alternately, acquiring land only for the least-expensive corridor leads to ecologically poor solutions. By imposing cost-constraints on the ecological optimization process, they achieved linkages with much better ecological values given budget constraints marginally above the feasible minimum-expenditure corridor design. Similarly, joint optimization for multiple species led to better connectivity while matching the acquisition costs associated with multiple individual-species corridor designs.

Ditmer M, Werden L, Tanner J, Vincent J, Callahan P, Laizzo P, Laske T, Garshelis D. 2019. Bears Habituate to the Repeated Exposure of a Novel Stimulus, Unmanned Aircraft Systems. *Conservation Physiology* 7(1):1-7. DOI:10.1093/conphys/coy067

Unmanned aircraft systems (UAS or "drones") provide new opportunities for data collection in ecology, wildlife biology and conservation. However, UAS may disturb animals more than other aerial survey methods due to the very nature of what makes these devices useful—the ability to fly and hover at low altitudes. Indeed, studies have observed responses of wildlife to UAS (Ditmer et al., 2015) demonstrating that black bears do not display behavioral signs of fear but, in extreme cases, their heart rate nearly quadrupled (162 bpm) compared to preflight baseline data (41 bpm).

Ditmer et al. used implanted cardiac bio-loggers to test whether American black bears habituate to repeated UAS exposure and whether tolerance levels persist during an extended period without UAS flights. Spiked heartrates of five captive black bears decreased across the five flights within each day and over the course of four weeks of twice-weekly exposure. After halting flights for 118 days, once flights resumed, heart rate responses were similar to that at the end of the previous trials.

The authors suggest that large mammals have the capacity to become and remain habituated to a novel anthropogenic stimulus in a relatively short time (3–4 weeks). However, such habituation to mechanical noises may reduce mammal wariness of other human threats, while potentially causing other chronic physiological effects not measured. Given the unknown chronic effects of continual disturbance, the authors strongly recommend that UAS users follow proper ethical guidelines when operating aircraft near wildlife.

Eklund A, López-Bao JV, Tourani M, Chapron G, Frank J. 2017. Limited Evidence on the Effectiveness of Interventions to Reduce Livestock Predation by Large Carnivores. *Scientific Reports* 7:2097. DOI:10.1038/s41598-017-02323-w

Effective mitigation of the negative impacts of large carnivores on humans, including livestock depredation, is critical for successful human-carnivore coexistence. It is essential for conservation practitioners, carnivore managing authorities, or livestock owners to know the effectiveness of various intervention techniques to reduce depredations in order to make informed management decisions.

Eklund et al. reviewed scientific literature (1990-2016) of intervention effectiveness and used a relative risk ratio to compare the various intervention options (i.e. changing livestock type, livestock enclosures, livestock guardian dogs, predator removal, using shock collars on carnivores, sterilization, scare devices).

Some interventions (i.e., livestock enclosure, livestock guardian dogs) reduced the risk of depredation, but the authors found minimal literature and scientific evidence on the effectiveness of interventions in general. They urge managers and stakeholders to move towards evidence-based large carnivore management practices and researchers to conduct controlled studies of intervention effectiveness.

Elfstrom M, Zedrosser A, Stoen O-G, Swenson JE. 2014. Ultimate and Proximate Mechanisms Underlying the Occurrence of Bears Close to Human Settlements: Review and Management Implications. *Mammal Review* 44:5-18. DOI:10.1111/j.1365-2907.2012.00223.x.

Large carnivores found near human settlements, and accessing human-derived foods—from livestock to garbage--are often considered "unnatural" and their existence forms a major obstacle for conserving large carnivore populations. However, bears have also been observed near human settlements without accessible human-derived foods, or without utilizing available human-related foods (McCullough 1982).

Focusing primarily on the brown bear, Elfstrom et al. analyzed previously published scientific data to determine ultimate and proximate mechanisms underlying the occurrence and behavior of bears near people, and specifically related to sex, age, and reproductive categories.

Elfstrom et al. found that bear behavioral strategies including avoidance of intraspecific aggression explain the type of bears occurring near humans better than naivety, human habituation, or food condition. Bears approaching human settlements should not be considered unnatural but, rather, individuals showing an adaptive behavior and using predation refuges as an ultimate mechanism of bears' despotic distribution.

Epstein Y. 2017. Killing Wolves to Save Them? Legal Responses to Tolerance Hunting in European Union and United States. *RECIEL* 26(1):19-29. DOI:10.1111/reel.12188

Wolves are protected by law in both the United States and the European Union. These laws restrict the harming or killing of individual members of protected species, but allow it in selective circumstances, such as when killing some individuals would benefit the species.

In both the US and the EU, there is pressure from constituents to allow the public hunting of wolves, in order to benefit the species by improving social tolerance for wolves. "Tolerance hunting" is built on the hypothesis that negative attitudes toward wolves leading to illegal killing will be ameliorated if individuals are allowed to legally kill wolves.

Summarizing the legal and scientific response of this theory, Epstein contrasts these legal responses to social tolerance hunting. American courts have repeatedly held that tolerance hunting, and other killing of animals to improve their public relations, is an inappropriate means for improving the status of protected species. Additionally, the author suggests that hunting wolves to achieve social acceptability likely violates EU law; yet, the EU court has not yet resolved the question, thereby allowing tolerance hunting to continue in member states including Sweden and Finland. The author opines that the EU's Habitats Directive should not be interpreted to allow tolerance hunting of strictly protected species.

Evans MJ, Hawley JH, Rego PW, Rittenhouse TAG. 2014. Exurban Land Use Facilitates Human-Black Bear Conflicts. *Journal of Wildlife Management* 78(8):1477-85. DOI:10.1002/jwmg.796.

The distribution and arrangement of habitats and human use areas are important to understanding where and why conflicts with wildlife occur; such data may inform proactive management activities to minimize conflicts. Black bear abundance and the number of human-black bear conflicts are increasing in the northeast United States, particularly in developed areas.

Evans et al. applied a spatial modeling approach to identify landscape variables associated with spatial intensity of human-black bear conflicts in Connecticut, and predicted where conflicts were most likely to occur in the future.

Likely conflict locations were determined by percent of forest cover and proportion of such forest classified as edge habitat. The authors attribute these results to Connecticut's exurban landscape, typical of New England, in which housing and natural land cover are extensively interspersed, as opposed to housing fragmenting natural land cover.

The authors suggest that these findings can inform town planners and developers in designing future housing to proactively minimize human-black bear conflicts. They also identified areas of high risk for conflict; the extent of these areas can help determine the scale of bear management units within which different management approaches are applied.

Evans MJ, Rittenhouse TAG, Hawley JE, Rego PW, Eggert LS. 2018. Spatial Genetic Patterns Indicate Mechanism and Consequences of Large Carnivore Cohabitation within Development. *Ecology and Evolution* 8:4815-29. DOI:10.1002/ece3.4033

The shift across North America and Europe from aggregated, high-density land-use patterns to low-density, exurban development means that recovering populations of large carnivores must increasingly interact with the human footprint. Large carnivores are especially susceptible to habitat fragmentation and interactions with anthropogenic features due to their low population densities, extensive ranges, and long generation times.

Evans et al. applied a spatial and landscape genetics approach to identify mechanisms explaining black bear persistence within developed areas in western Connecticut and model changes in gene flow resulting from interaction with development. They found that increased development disturbed spatial genetic structures; female philopatry was disrupted around increased development and the authors noted asymmetrical male immigration into more developed areas. Altered dispersal behavior and sex ratios indicate a potentially detrimental shift in ecological dynamics.

This study illustrates the potential for intermixed development to alter wildlife population dynamics. Evans et al. contend that dispersal behavior is condition-dependent and indicates the potential for landscapes intermixing development with natural land cover to facilitate shifts to increased dispersal.

Finnegan L, Pigeon K, Cranston J, Hebblewhite M, Musiani M, Neufeld L, et al. 2018. Natural Regeneration on Seismic Lines Influences Movement Behavior of Wolves and Grizzly Bears. *PLoS ONE* 13(4):e0195480. DOI:10.1371/journal.pone.0195480

One of the most pervasive disturbances within caribou ranges in Alberta, Canada, are seismic lines cleared for energy exploration. Seismic lines facilitate predator movement, and although vegetation on some seismic lines is regenerating, it remains unknown whether vegetation regrowth is sufficient to alter predator response.

Addressing this knowledge gap, Finnegan et al. used Light Detection and Ranging (LiDAR) data, and GPS locations, to understand how vegetation and other attributes of seismic lines influence movements of wolves (*Canis lupus*) and grizzly bears. They found that wolves moved toward seismic lines indiscriminate of height during winter months, while preferring taller heights in the spring and shorter heights (<1m) in the summer. Seismic lines with shorter heights were preferred by grizzly bears in spring and summer months.

These results indicate that wolves use linear, seismic lines for greater speed of travel through landscapes, augmenting predation potential of Caribou. The authors state that results did not clearly indicate whether grizzly bears used seismic lines for movement potential or foraging opportunities. Consequently, the authors argue for exploring methods to reduce wolf response to seismic lines including active restoration tactics like blocking seismic lines and tree planting, along with management of alternate prey.

Fowler NL, Belant JL, Beyer DE. 2019. Non-Linear Relationships Between Human Activities and Wolf-Livestock Depredations. *Biological Conservation* 236:385-92. DOI:10.1016/j.biocon.2019.05.048

Identifying factors influencing livestock depredations has provided insights into behavioral ecology of carnivores and methods of conflict prediction and mitigation. However, as human development continues to expand, evaluating depredations based on human activities may help identify mitigation strategies to further facilitate coexistence. Fowler, Belant and Beyer examined the relationship between depredations by grey wolves (*Canis lupus*) and various attributes of human activity including livestock abundance, distance to human settlements, proportion of agricultural lands and road density.

Using data on verified depredations by grey wolves from Michigan's Upper Peninsula (UP), along with land use and census data, the authors assessed variation in covariates across three scales. They

observed that the density of humans, cattle, and proportion of agricultural land increased the probability of depredation up to a certain point, before limiting depredation probability as density continued to rise. The authors attribute this pattern to shifting wolf perceptions of reward and risk in areas of high human activity.

Behavioral responses of animals reflect trade-offs of perceived risks and benefits. Fowler, Belant and Beyer demonstrate the facilitative and inhibitory effects of human activities on wolf-livestock depredation probability.

Fremier AK, Kiparsky M, Gmur S, Aycrigg J, Craig RK, Svancara LK, Goble DD, Cosens B, Davis FW, Scott JM. 2015. A Riparian Conservation Network for Ecological Resilience. *Biological Conservation* 191: 29-37. DOI: 10.1016/j.biocon.2015.06.029.

A crucial gap exists between the static nature of existing protected areas in the U.S. and the dynamic impacts of 21st century stressors, including habitat loss and fragmentation and climate change. Connectivity is a valuable element for bridging the gap and building the ecological resilience of existing protected areas; however, creating terrestrial connectivity by designing individual migration corridors across fragmented landscapes is arguably untenable at a national scale.

Fremier et al. explored the potential for use of riverine corridors in a riparian connectivity network (RCN) as a potential contributor to a more resilient network of protected areas. They found that the spatial backbone for an RCN is already in place, and that such networks could connect protected areas and have a higher rate of conservation management than terrestrial lands. Further, they suggest that conservation is better served if riparian connectivity is part of a larger landscape connectivity strategy.

Gaynor K, Hajnowski C, Carter N, Brashares J. 2018. The Influence of Human Disturbance on Wildlife Nocturnality. *Science* 360(6394):1232-35. DOI:10.1126/science.aar7121

Human presence can instill strong fear in wild animals, which may adjust their activity to avoid contact with humans. As in natural predator-prey systems, such risk avoidance can have important nonlethal effects on animal physiology and fitness, affecting demography and triggering trophic cascades. While rapid expansion of human activity has driven well-documented shifts in the spatial distribution of wildlife, the cumulative effect of human disturbance on the temporal dynamics of animals yet to be quantified.

Gaynor et al. examined anthropogenic effects on mammal diel activity patterns, conducting a meta-analysis of 76 studies of 62 species from six continents. Results from the global study revealed humans have a strong effect on daily patterns of wildlife activity, causing observed increases in wildlife nocturnality by an average factor of 1.36. Mammals across continents, habitats, taxa, human activities, and all body size classes showed a strong response to human activity—although there was a slight trend toward a greater response among larger-bodied species, including carnivores, who may be hunted or persecuted to greater degrees than other species.

The authors argue that fear of humans is the primary mechanism driving the increase in wildlife nocturnality, given its prevalence across activity types and the widespread evidence that mammals perceive and respond to risk from people.

Gehring TM, VerCauteren KC, Landry J. 2010. Livestock Protection Dogs in the 21st Century: Is an Ancient Tool Relevant to Modern Conservation Challenges? *BioScience* 60(4):299-308.
DOI:10.1525/bio.2010.60.4.8

Livestock protection, or guarding, dogs (LPD) function as disruptive-stimulus tools to repel predators. They also function as aversive-stimulus tools that can cause predators to modify their behavior. As such, they can be among the most efficient tools for reducing predator-livestock conflicts. They can be used as proactive prevention tools and to reduce reliance on reactionary conflict management. LPDs can also confer psychological benefits to producers by lowering stress and perceived-threat levels.

LPDs have been reported to lower sheep depredations by brown and black bears, as well as mountain lions. There is conflicting testimony regarding relative effectiveness of LPDs in fenced pasturage as opposed to open-range ranches, although they seem to be least effective where livestock are widely dispersed (not flocked/herded) and where producers spend only minimal time monitoring their livestock. Cost benefit analyses suggest that the majority of producers using LPDs value them as economic assets.

There are not many quantitative studies of LPDs. Almost all research is anecdotal and qualitative. Most empirical evidence involves sheep and coyotes, with positive results. The primary consensus is that LPDs are good at protecting livestock against predation, and that money is saved and depredation decreases when LPDs are present. Gehring et al. argue that LPDs can help prevent depredation before it becomes a problem. They recommend that LPDs be used with a combination of other methods for protection, but point out that LPDs can allow producers to be more self-reliant in protecting their own livestock.

Gehring TM, VerCauteren KC, Cellar AC. 2011. Good Fences Make Good Neighbors: Implementation of Electric Fencing for Establishing Effective Livestock-Protection Dogs. *Human-Wildlife Interactions* 5(1):106-11.

To be effective, livestock protection dogs (LPD) must defend livestock from predators, and to do so they must stay with livestock. Many existing guidelines stress the importance of bonding dogs to livestock. Although strong socialization is paramount for success, socialization alone may not prevent unattended dogs from roaming.

Gehring et al. suggest that electric fencing maintained for livestock can be a particularly effective tool in this regard, and may require only slight modifications for purposes of preventing roaming behavior in protection dogs. Proper training of dogs around electric fencing is critical in this process. In operations that already utilize electric fencing to manage grazing, this infrastructure can be applied to training and managing protection dogs.

Gilbert S, Sivy K, Pozzengharra C, DuBour A, Overduijn K, Smith MM, Zhou J, Little JM, Prugh LR. 2016. Socioeconomic Benefits of Large Carnivore Recolonization Through Reduced Wildlife-Vehicle Collisions. *Conservation Letters* 10(4): 431-39. DOI:10.1111/conl.12280

The global decline of large carnivores has led to dramatic ecosystem changes, including increased herbivore abundance and decreased biodiversity. Herbivore-vehicle collisions kill thousands and injure

tens of thousands of people annually in regions where large carnivores have been extirpated. Attempts to control overabundant deer in the eastern United States have largely failed, and deer-vehicle collisions continue to rise at alarming rates. Recolonization by large carnivores could provide an efficient solution to the problem of deer overabundance

Gilbert et al. present the first valuation of an ecosystem service provided by large carnivore recolonization, using deer-vehicle collision reduction by cougars as a case study. Coupled deer population models and socioeconomic valuations revealed that cougars could reduce deer densities and DVCs by 22% in the eastern U.S., preventing 21,400 human injuries, 155 fatalities, and $2.13 billion in avoided costs within 30 years of establishment. Further, results of empirical data from South Dakota suggest that cougar recolonization is already providing this valuable ecosystem service.

While cougars attack people, livestock, and pets, if introduced to the eastern U.S., estimates indicate cougars would indirectly save far more people from death (5 per year) and injury (680 per year) by reducing deer-vehicle collisions than they would likely directly kill (<1 per year) or injure (5 per year). The authors suggest that large carnivore restoration could provide valuable ecosystem services through such socioecological cascades, and these benefits could offset the societal costs of coexistence.

Graves R, Williamson M, Belote T, Brandt J. 2019. Quantifying the Contribution of Conservation Easements to Large-Landscape Conservation. *Biological Conservation* 232:83-96. DOI:10.1016/j.biocon.2019.01.024

Protected areas, including public lands and reserves, are crucial for persistence of species and ecosystems threatened by land-use change and habitat loss (Butchart et al. 2015; Woodley et al. 2012). In the United States, growth of the public land system has stagnated (USGSGAP, 2016) and the current pattern of public lands and reserves does not provide sufficient ecosystem representation or protections for numerous species. Private lands interspersed between larger public lands are critical for species movement (Shafer, 2015). Increasingly, conservation easements (CE) are used as a tool to protect private land from future development; yet, few studies have examined whether contemporary patterns of CE effectively contribute to landscape-scale biodiversity and ecosystem conservation goals.

Graves et al. analyzed the distribution of 1223 CE established between 1970 and 2016 in the High Divide, a region dominated by public lands that is of national conservation importance in the Rocky Mountains. Despite the addition of CE to protected areas networks, results indicated insufficient representation for 43 out of 87 ecosystems (<5% representation on land managed for biodiversity). Protection of priority ecosystems varied across CE and illustrated potential mismatches between regional- and national-scale conservation goals.

Further, at regional scales, current CE patters performed only slightly better for conservation potential than areas chosen at random with respect to providing for landscape connectivity. To be effective, the authors suggest that regional networks of protected areas must be representative of the biodiversity and ecosystem processes present in the region.

Grilo C, Lucas PM, Fernández-Gil A, Seara M, Costa G, Roque S, Rio-Maior H, Nakamura M, Álvares F, Petrucci-Fonseca F, Revilla E. 2018. Refuge as a Major Habitat Driver for Wolf Presence in Human-Modified Landscapes. *Animal Conservation* 22(1). DOI:10.1111/acv.12435

During the 20th century, human encroachment and direct persecution led to severe declines in large carnivore populations across Europe and North America. Some populations have managed to survive in human-modified landscapes, and conservation-oriented legislation, along with widespread abandonment of rural areas for urban centers, have allowed for the recovery of some native carnivore species. An understanding of environmental determinants of species occurrence is important for designing science-based conservation and management strategies.

Grilo et al. analyzed key environmental factors describing habitat quality for wolves in the Iberian Peninsula in order to understand how landscape features, human disturbance, and prey availability affect wolf distribution and space use. The authors ran distribution models at three spatial scales, using two distribution modelling approaches to ensure consistent results.

Grilo et al. identified a complex topography and avoidance of highly humanized areas as the main factors in determining wolf presence in the Iberian Peninsula. They conclude that human-modified landscapes with refuge availability, as defined by complex topography, are conducive to human-wolf coexistence.

Gunther KA, Haroldson MA, Frey K, Cain SL, Copeland J, Schwartz C. 2004. Grizzly Bear-Human Conflicts in the Greater Yellowstone Ecosystem, 1992-2000. *Ursus* 15(1):10-22. DOI:http://dx.doi.org/10.2192/1537-6176(2004)015<0010:GBCITG>2.0.CO;2.

For many years, translocation was the common solution for managing individual grizzly bears that came into conflict with humans. This usually provided only temporary alleviation instead of long-term solutions. Gunther et al. argue that wildlife managers need to be able to predict the proximal causes, types, locations, and trends of conflicts in order to more efficiently allocate limited resources for proactive rather than reactive management actions. They recorded and analyzed trends in grizzly bear-human conflicts over time, in and around the Yellowstone Grizzly Bear Recovery Zone (YGBRZ).

Numbers of conflicts generally increased from spring through early and late hyperphagia, and livestock depredations peaked during early hyperphagia. The number of conflicts involving property damage and anthropogenic foods, human injuries, gardens and orchards, and beehives all had similar patterns—peaking during late hyperphagia.

Occupied grizzly bear range has expanded dramatically over the past 30 years. Gunther et al. predict that depredations and conflicts will likely continue to increase if the area occupied by bears continues to increase and overlap areas of human use and habitation.

The authors make special note that the majority of recorded grizzly bear-human conflicts occurred in six locations of human activity. Identifying and targeting conflict hotspots such as these is a wise use of resources. Most livestock depredations involved cattle, and almost all of those depredations occurred in Wyoming (very few occurred in Montana, despite presence and range overlap between bears and cattle). If current practices in Wyoming might be changed to reduce depredations, this would be a cost-effective benefit to livestock producers there.

The authors note that permanent removal of chronic depredators has been an effective method of alleviating livestock losses while having minimal impact on the long-term survival of the broader population. Additionally, they note that grizzly bears and domestic sheep are not generally compatible, and the authors recommend incentivizing the retirement of sheep grazing allotments that are positioned in important core grizzly bear habitats. They recommend use of electric fence to protect vulnerable livestock such as sheep on bed-grounds, as well as to deter bears from garbage, beehives, and other attractants. The authors also suggest the strategic use/expansion of food and garbage storage orders in conflict-prone areas.

Gunther KA, Shoemaker RR, Frey KL, Haroldson MA, Cain SL, van Manen FT, Fortin JK. 2014. Dietary Breadth of Grizzly Bears in the Greater Yellowstone Ecosystem. *Ursus* 25(1):60-72. DOI:10.2192/ursus-d-13-00008.1

Grizzly bears in the Greater Yellowstone Ecosystem (GYE) are opportunistic omnivores that eat a great diversity of plant and animal species. Changes in climate may affect regional vegetation, hydrology, insects, and fire regimes, likely influencing the abundance, range, and elevational distribution of the plants and animals consumed by GYE grizzly bears.

Determining the dietary breadth of grizzly bears is important to document future changes in food resources and how those changes may affect the nutritional ecology of grizzlies.

Gunther et al. conducted a review of available literature and compiled a list of species consumed by grizzly bears in the GYE. They documented more than 266 species within 200 genera from 4 kingdoms, including 175 plant, 37 invertebrate, 34 mammal, 7 fungi, 7 bird, 4 fish, 1 amphibian, and 1 algae species, as well as 1 soil type consumed by GYE grizzly bears.

Gunther KA, Wilmot KR, Cain SL, Wyman T, Reinertson EG, Bramblett AM. 2018. Managing Human-Habituated Bears to Enhance Survival, Habitat Effectiveness and Public Viewing. *Human-Wildlife Interactions* 12(3). DOI:10.26077/83cn-mh23

Increases in public visitation to national parks have led to more bears becoming habituated to human activity. In some contexts, habituation can predispose bears to being exposed to and rewarded by anthropogenic foods, which can lower survival rates.

As part of a case study, Yellowstone and Grand Teton National Parks implemented several proactive strategies to mitigate negative aspects of bear habituation including: providing park visitors with educational information on bear viewing etiquette; managing roadside viewing opportunities; installing bear-resistant infrastructure; hazing bears from developments; enforcing food and garbage storage regulations; and making human activities as predictable as possible for bears. In both locations, these efforts have helped decrease the presence of food-conditioned bears, while providing opportunities for visitors to learn about and appreciate bears.

The authors maintain that sustaining and expanding programs that not only set appropriate boundaries for habituated bears, but also manage human behavior through education and outreach, is essential for minimizing the negative impacts of human activity in bear habitat and for bear conservation.

Hanley Z, Cooley H, Maletzke B, Wielgus R. 2018. Cattle Depredation Risk by Gray Wolves on Grazing Allotments in Washington. *Global Ecology and Conservation* 16:e00453.
DOI:10.1016/j.gecco.2018.e00453

Livestock depredation was a primary factor in wolf extirpation from most of the conterminous United States by the 1930's. Through reintroductions and natural dispersals, gray wolves have recolonized portions of their former range. Within this range, livestock grazing lands include 31% of wolf-occupied areas in Idaho, Montana, and Washington, causing potential for livestock-carnivore conflicts

Hanley et al. investigated characteristics of cattle grazing allotments in Idaho, Montana, and Washington to predict cattle depredation risk on grazing allotments in current and probable wolf-occupied areas of Washington. Their findings predicted increased probabilities of depredations for allotments with higher cattle and wolf density. Assuming pack sizes of five to ten wolves, between 10% and 15% of cattle grazing allotments in Washington were forecasted at 61% depredation probability.

The authors identified areas in which wildlife and rangeland management agencies can focus proactive depredation prevention measures. However, the authors suggest additional fine-scale data (e.g., GPS locations of depredation locations and wolf core areas, animal husbandry practices, actual number of cattle by age class) are needed to improve model performance and further evaluate cattle depredation risk by wolves on grazing allotments in Washington.

Hanley Z, Cooley H, Maletzke B, Wielgus R. 2018. Forecasting Cattle Depredation Risk by Recolonizing Grey Wolves. *Wildlife Biology* 2018(1). DOI:10.2981/wlb.00419

Large carnivore attacks on livestock and subsequent carnivore removal have led to conflict between farming communities and conservation practitioners worldwide. Minimizing wolf-livestock conflicts requires identifying conditions that place livestock at risk and focusing adaptive management at a local scale. Nonlethal preventative methods (e.g. range riders and shepherds, guard dogs, carcass removal) and lethal removal of wolves are currently used to deter livestock depredation. Since lethal removal could delay recovery objectives, it is important to implement proactive, science-based preventative methods to mitigate livestock depredation by wolves as recolonization occurs.

Using generalized linear mixed models, Hanley et al. investigated characteristics of wolf pack territories in Idaho and Montana from 1991 through 2008 to predict cattle depredation risk by a recolonizing wolf population in Washington. The initial results showed that a decrease in forest cover best predicted cattle depredation risk in Idaho and Montana where most cattle depredations were found on un-forested private pastures, but did not adequately predict risk for forested public lands in Washington. The key findings from the model set without forest cover indicated relative cattle abundance in wolf pack territories, and cattle depredation the previous year had the greatest effect on cattle depredation risk in Idaho and Montana.

The authors suggest that these risk models and maps provide locations for federal and state wildlife managers to focus depredation prevention measures and a template for future analyses as wolves continue to recolonize Washington.

Haswell PM, Shepherd EA, Stone SA, Purcell B, Hayward MW. 2019. Foraging Theory Provides a Useful Framework for Livestock Predation Management. *Journal for Nature Conservation* 49:69-75. DOI:10.1016/j.jnc.2019.03.004

Scientific theory can offer useful frameworks for applied conservation issues, such as mitigating livestock depredations by carnivores. Haswell et al. argue that lethal control of predators, while a solution for livestock producers, is unjustifiable relative to carnivore conservation, ecological integrity, and financial costs. Non-lethal tools and practices can provide an effective alternative, especially in light of the fact that livestock production is likely to continue to as a major land use and carnivore conservation challenge.

Foraging theory, which suggests that animals attempt to make the best of foraging scenarios by trading-off costs against benefits, can provide a useful framework for studying and managing livestock predation. Livestock predation is influenced by carnivore foraging ecology and risk, which may provide an opportunity to reduce predation and facilitate coexistence. In this context, the theory suggests that where food patches can be depleted, animals should abandon such places when gains no longer outweigh the costs (i.e., energetic costs, predation costs, missed opportunity costs). Haswell et al. advise practitioners and wildlife managers to apply this theory to the issue of livestock depredation by making livestock less "profitable" than wild prey, thus positively manipulating predator foraging behavior.

Hebblewhite M. 2011. Unreliable Knowledge about Economic Impacts of Large Carnivores on Bovine Calves. *Journal of Wildlife Management* 75(8):1724-30. DOI:10.1002/jwmg.206.

Hebblewhite critiques a study situated in western Wyoming's Upper Green River Allotment, which concluded that recolonizing predators increase bovine calf mortality rates. The authors of that study compared calf loss rates before and after carnivore recovery, and concluded that increasing wolf and grizzly bear populations increased calf losses.

The author's third-party re-analysis of the data revealed a much more nuanced picture complicated by a statistically confounded set of factors. He found that calf loss rates were a result of stocking densities, precipitation, area, reporting rate bias, *as well as* predation during periods when wolves and grizzly bears were present.

Stocking density is perhaps the most important husbandry practice that can be modified by ranchers, and it affects both adult and calf productivity and weight gain. Predation and food competition can both be density dependent. Low summer precipitation also increases calf loss rates, which may suggest that drought effects render calves more susceptible to mortality. This is also consistent, however, with predator-induced stress hypotheses. These 3 potential mechanisms are all consistent with increasing susceptibility of calves to predation, and highlight the weakness of observational studies in revealing mechanistic explanations for mortality patterns.

Hebblewhite points out that the personal values of stakeholders can also contribute to increased perceptions of conflict when none in fact exist. His reanalysis found some support for such an observer expectancy bias. His discussion highlights the complexity of causal factors related to livestock-carnivore conflict and predation. Results-based analysis should generally be examined carefully, precisely because of the behavioral and biological complexity associated with predation.

Hiller TL, McFadden-Hiller JE, Jenkins SR, Belant JL, Tyre AJ. 2015. Demography, Prey Abundance, and Management Affect Number of Cougar Mortalities Associated with Livestock Conflict. *Journal of Wildlife Management* 79(6):978-988. DOI:10.1002/jwmg.913.

As some large carnivore populations recover because of conservation efforts, managing livestock-carnivore and human-carnivore conflicts to the satisfaction of all stakeholders has become increasingly challenging, especially in regard to cougars, which are not viewed as favorably as other carnivores (Kellert et al. 1996). To inform decisions for balancing social and ecological considerations in cougar management, Hiller et al. assessed factors associated with number of cougars killed due to livestock conflicts. Factors considered included wild and domestic prey availability, land cover, human population, hunter harvest, and other characteristics. Assessment was conducted on data gathered between 1990 and 2009 at the county level in the state of Oregon.

Focusing on cougar density, Hiller et al. found that cougar mortalities resulting from livestock conflicts did not increase as the density of cougars harvested increased when the estimated cougar population was at minimum (30/10,000 km2) or mean (200/10,000 km2) values, and remaining independent variables were held constant at their respective mean values. However, when the estimated cougar population density was at maximum (500/10,000 km2), the density of cougar mortalities related to livestock conflicts decreased with increasing harvest density.

Although Hiller et al. could not provide evidence of a causal relationship, mortality densities related to hunter harvest and to conflicts with livestock appear to have an inverse relationship within the limits of their data. These results indicate that hunter harvest may be a useful tool in managing conflicts under some circumstances, such as in Oregon. Additional strategies could include removing some or all livestock from areas of low deer density, decreasing deer harvest, or increasing prey densities.

Hogberg J, Treves A, Shaw B, Naughton-Treves L. 2014. Changes in Attitudes Toward Wolves Before and After an Inaugural Public Hunting and Trapping Season: Early Evidence from Wisconsin's Wolf Range. *Environmental Conservation* 43(1):1-15. DOI:10.1017/S037689291500017X

Negative attitudes toward large carnivores can stem from conflicts with the species such as depredation of domestic animals, fear for personal safety, and perceived compensation for game species. However, attitudes toward large carnivores are not solely determined by conflicts and direct costs associated with living in proximity. Understanding public attitudes has the potential to guide policymakers to implement politically acceptable solutions that may balance wildlife conservation with human needs. Negative attitudes may lead to poaching and carnivore killing. In many areas, wildlife managers are turning to hunting programs to increase public acceptance of predators.

Hogberg et al. examined attitudes toward wolves before and after a hunting and trapping season in Wisconsin; results ultimately cast doubt on the assumption that hunting programs promote public acceptance of large carnivores. Although the majority (66%) of wolf range respondents approved of the decision to hold the hunt, the results indicate a negative trend in attitudes toward wolves among male respondents and hunters living in wolf range. These negative attitudes existed both before and after the state's first legal hunt, suggesting that hunting was not associated with an increase in tolerance for the species after one year.

To mitigate respondents' increasing belief that killing wolves is the only way to stop them from threatening animals and pets, the authors suggest that future research explore attitudes toward nonlethal means of reducing depredation from wolves, such as anti-predator fencing, strobe light/siren devices, and livestock guarding animals. The authors urge managers to not focus solely on risks and conflict in public communication, but also include benefits of carnivore conservation including ecosystem health or the aesthetic value of viewing wildlife within communications.

Holland KK, Larson LR, Powell RB. 2018. Characterizing Conflict Between Humans and Big Cats *Panthera spp*: **A Systematic Review of Research Trends and Management Opportunities.** *PLoS ONE* 13(9):e0203877. DOI:10.1371/journal.pone.0203877

Big cats (*Panthera* spp.), a taxonomic group that includes tigers, lions, leopards, and snow leopards, are apex carnivore species that drive the function and structure of biological communities in diverse ecosystems around the world. Many big cat species are endangered, threatened, or vulnerable, and conservation efforts aimed at preserving these species has the potential to produce significant biodiversity gains across multiple taxa.

Holland, Larson and Powell conducted a systematic literature review to explore the current state of knowledge regarding human-*Panthera* conflicts, conflict interventions, and management recommendations. Their synthesis revealed several data gaps and research needs, such as a need to evaluate the efficacy of conflict mitigation strategies. The results of their review can be used to inform future research and management efforts focused on human-*Panthera* conflict and ultimately enhance the potential for coexistence between humans and carnivore species.

Hughes C, Nielsen SE. 2019. 'Bear are Only the Lightning Rod': Ongoing Acrimony in Alberta's Grizzly Bear Recovery. *Society and Natural Resources* 32(1):34-52. DOI:10.1080/08941920.2018.1502853

Human wildlife conflicts are especially pervasive in contexts where people depend natural resource production. Conservation policies are sometimes viewed as an imposition by rural people whose livelihoods are dependent on natural resources, and this controversy limits conservation achievements. Hughes and Nielsen suggest that understanding the human side of carnivore conservation and policy processes is necessary for achieving desired outcomes.

Hughes and Nielsen used a social constructionist approach to explore what grizzly bear (*Ursus arctos*) recovery in Alberta, Canada, means for people expected to live alongside the bears. The authors conducted interviews with homesteaders, frontiersmen, exurbans, and government biologists and officers to learn about perspectives, values, knowledge, experiences, and strategies for dealing with grizzly bears.

The authors argue that grizzly bear recovery processes must ensure the people who live alongside bears are not alienated from policy participation and are given opportunities to clarify their perspectives, values, demands, and expectations. Enabling the conditions to fulfill human dignity desires across a socially diverse landscape is more likely to enable constructive dialog and successful outcomes for human-bear coexistence.

Jacobs CE, Main MB. 2015. A Conservation-Based Approach to Compensation for Livestock Depredation: The Florida Panther Case Study. *PLoS ONE* 10(9). DOI:10.1371/journal.pone.0139203.

Conflict between large carnivores and humans is a global issue that has become an important aspect of large carnivore conservation. Livestock depredation is often the principal reason for this conflict and can lead farmers to kill predators in retaliation or as a preventative measure (Inskip and Zimmerman (2009) As a result, livestock depredation is considered one of the driving forces behind the worldwide decline of large carnivores (Inskip and Zimmerman 2009, Nelson 2009, Ripple et al. 2014). While compensation programs are often established to address the issue of livestock depredation, some of the most common programs are highly criticized due to problems such as moral hazard (Swenson and Anden 2005, Zabel and Holm-Muller 2008), high transaction costs (Saberval et al. 1994), unconfirmed losses, and the difficulty of finding depredations (Zabel and Holm-Muller 2008, Montag 2003). It is therefore important to consider new approaches to compensation programs in order to conserve and, where needed, recover large carnivore species.

Jacobs and Main studied the impact of panthers on Florida's ranching industry to quantify calf depredation, and to develop a habitat suitability model to evaluate the quality of panther hunting habitat on ranchlands, assess whether the model could predict predation risk, and discuss its potential for inclusion in an incentive-based compensation program.

The authors found that if large carnivore conservation and recovery is dependent on maintaining suitable habitat on private lands, strategies designed to compensate and incentivize landowners for managing large carnivore habitat will promote conservation efforts. Their panther hunting habitat model represents an approach that may be useful for addressing livestock depredation conflicts for other carnivores and areas worldwide by providing a means to prioritize and categorize private lands for participation in a PES program that incentivizes the conservation of large carnivore habitat and compensates landowners for the associated risks to livestock.

Jakes A, Jones P, Paige C, Seidler R, Huijser M. 2018. A Fence Runs Through it: A Call for Greater Attention to the Influence of Fences on Wildlife and Ecosystems. *Biological Conservation* 227:310-18. DOI:10.1016/j.biocon.2018.09.026

Linear transport and energy infrastructures (e.g., roads, pipelines, power lines, canals) often have negative impacts on native wildlife and ecological processes through direct mortality, creating barriers and hazards, or altering behavior. Fencing is nearly ubiquitous yet has received far less research attention than roads, powerlines, and other types of linear infrastructure. Worldwide, lands are laced with countless kilometers of fences erected by diverse stakeholders at different scales for widely varying purposes. Collectively, fences form extensive and irregular networks stretching across landscapes, and their influence on wildlife and ecosystems is likely far-reaching.

Jones et al. conduct an empirical investigation of fencing, including its global prevalence, fencing functions and designs, and a review of fencing pros and cons relative to wildlife conservation. They conclude by identifying knowledge gaps and suggest research needs in fence ecology.

The authors argue that a more holistic understanding of fence ecology will open extensive opportunities to shape conservation at broad scales. Further they suggest that innovative research will provide better

understanding of the cumulative and broad-scale influences of fences on populations and ecosystem processes and help develop designs and mitigations that reduce fence impacts.

Jochum KA, Kliskey AA, Hundertmark KJ, Alessa L. 2014. Integrating Complexity in the Management of Human-Wildlife Encounters. *Global Environmental Change* 26:73-86. DOI:10.1016/j.gloenvcha. 2014.03.011.

Along with urbanized landscapes and human population growth, the difficulty of predicting human behavior, coupled with changes in human behavior over space and time, and additional scales (Cash et al. 2006), are major challenges for today's wildlife managers. Conservation not only aims to increase wildlife population size, but also to maintain biological diversity, thereby keeping wildlife at sustainable population levels. In addition, there has risen a growing demand for more robust theories and methodologies to enable and guide effective human-wildlife management.

Jochum et al. argue that human-wildlife encounters can only be understood and modified toward resilient relationships when treated as a complex social-ecological system, but no structured behavior theory exists on how to address these management challenges.

This study, using their Integrated Adaptive Behavior Model, is a first attempt to do so through assembling and analyzing existing social-psychological, human-environment, and human-wildlife behavior theories and models in regard to their relevance to human-wildlife encounters.

Johansson M, Merreira IA, Stoen O-G, Frank J, Flykt A. 2016. Targeting Human Fear of Large Carnivores—Many Ideas but Few Known Effects. *Biological Conservation* 201():261-69. DOI:10.1016/j.biocon.2016.07.010.

There is a range of potential management measures aimed at reducing the number of interactions between humans and large carnivores, such as fencing livestock, removing attractants, and hunting (Shivik 2014). The acceptability of such measures, in particular lethal management, is partly associated with human emotions, including feelings of fear (Jacobs et al. 2014, Lute et al. 2014, Pohja-Myrkä and Kurki 2014). However, evaluations of the effectiveness of these management measures rarely address the social or human aspects, such as the potential to reduce individual feelings of fear (Treves et al. 2009, Maheshwari et al. 2014, Frank et al. 2015).

In the literature, interventions are frequently proposed for addressing negative human responses to large carnivores, but little is known about the actual potential to reduce people's fear (Gore et al. 2006, Gusset et al. 2008).

Johansson et al. reviewed the scientific literature on interventions put forward to reduce human fear of large carnivores, with the objective of summarizing the current state of knowledge. The authors defined interventions as any action to mitigate human-large carnivore conflict that may be initiated or used by an individual person, an organization, or an authority. In this context, they considered conflicts as any undesired interaction, direct or indirect, between human and large carnivore.

The authors identified four major categories of intervention, each of which has the potential to reduce fear responses. They consider the literature on the effect of interventions address human fear of large

carnivores to be scared and partly contradictory, which they suggest makes it difficult for wildlife managers to rely on current research when designing appropriate interventions.

Johnson H, Lewis D, Verzuh T, Wallace C, Much R, Willmarth L, Breck S. 2017. Human Development and Climate Affect Hibernation in a Large Carnivore with Implications for Human–Carnivore Conflicts. *J Appl Ecol* 55:663-72. DOI:10.1111/1365-2664.13021

While the influences of land use and climate change on wildlife and their habitats are well recognized, there is growing recognition that these factors can significantly increase human–wildlife conflicts. The initial response of wildlife to changing environmental conditions is typically a shift in behavior, but little is known about the effects of these stressors on hibernation behavior, an important life-history trait that can subsequently affect animal physiology, demography, interspecific interactions, and human-wildlife interactions.

Using GPS collar data from 131 den events of adult female bears, Johnson et al. employed fine-scale animal habitat information to evaluate the relative and cumulative influence of natural food availability, anthropogenic food, and weather on the start, duration, and end of black bear hibernation. Of the habitat conditions evaluated, warmer temperatures tended to be most influential, delaying the onset of hibernation in the fall, expediting emergence from hibernation in the spring, and reducing the overall duration of hibernation. Additionally, increased availability of natural and human foods had similar effects as good natural food conditions and high use of anthropogenic subsidies both delayed the start of hibernation and reduced its duration.

Given that warmer temperatures and human development both reduced hibernation in the study, the authors predict that future trajectories of climate and land use change may increase the length of the active bear season, with the potential to cause subsequent increases in human–bear conflicts and bear mortalities, especially in the fall. With expected trajectories of climate and land use change, and likely associated shifts in black bear behavior, the authors argue that it will be increasingly important for wildlife agencies to use reliable demographic methods to monitor bear populations, rather than trends in conflicts or mortalities.

Kendall KC, Stetz JB, Boulanger J, Macleod AC, Paetkau D, White GC. 2009. Demography and genetic structure of a recovering grizzly bear population. *Journal of Wildlife Management* 73(1)3-17. DOI:10.2193/2008-30.

Northern Continental Divide Ecosystem (NCDE) grizzly bear populations appear to be growing in terms of abundance, occupied habitat, and connectivity in areas of historically low genetic interchange. It appears that the population has generally remained genetically integrated and connected to Canadian populations. Data collected by Kendall et al. suggest that it has experienced no severe genetic bottleneck, and that connectivity within the population has also remained largely intact.

Recent decreases in genetic differentiation and apparent expanded distribution in the NCDE are consistent with population growth, although there is no comprehensive and reliable ecosystem-wide trend data to compare census data with. The number and distribution of detected females may also

bode well for the population. These results suggest that the NCDE grizzly bear population may be faring better than indicated by the USFWS monitoring program.

There does appear to be incipient fragmentation along the major transportation corridor in the NCDE, and unmitigated development along that corridor may lead to reduced gene flow within the NCDE population and reduced connectivity to adjacent populations. Increased traffic volume and development along other transportation corridors in the NCDE carries similar risks. Long-term management strategies for this population should include ways to facilitate continued genetic interchange across transportation corridors and the associated development that tends to grow along them.

The known human-caused mortality rate in 2004 (when calculated with abundance estimates based on this study's data) was slightly above the 4% level considered sustainable. The 2004 female mortality rate was double the level allowed in the Recovery Plan. This is noteworthy because female survival appears to be the most important driver of population trend.

Kertson BN, Spencer RD, Marzluff JM, Hepinstall-Cymerman J, Grue CE. 2011. Cougar Space Use and Movements in the Wildland-Urban Landscape of Western Washington. *Ecological Applications* 21(8):2866-81. DOI:10.1890/11-0947.1.

Residential development of natural landscapes is substantial and influential. This development affects the long-term viability of many wildlife species. Although they are primarily associated with wildlands, cougars can and do use areas with an extensive human presence. Understanding the spatial ecology of cougars along a gradient of human residential development —in order to decrease the occurrence of cougar-human interactions—is a principal challenge for cougar managers. Cougars are considered habitat generalists, but the presence of sufficient prey, along with landscape cover for stalking, resting, and rearing young, are usually prerequisites for use.

Kertson et al. examined cougar space use and movement in a mixed wildland-residential study area in western Washington, USA. They found that cougars concentrated their use in prey-rich areas with advantageous foraging characteristics and a limited anthropogenic presence. Maximizing predation opportunities and minimizing exposure to residential development appear equally important to cougars in a wildland-urban environment, and may not be mutually exclusive. Cougars in this setting use the landscape in ways that minimize the potential for interactions with people while remaining consistent with their role as an apex predator in Pacific Northwest ecosystems. Cougars appeared to employ a flexible hunting strategy using areas where principal and alternative prey species are abundant and/or vulnerable.

Lethal control is often the default management strategy to reduce cougar-human interactions. The authors argue that this strategy is incomplete, because it fails to account for cougar spatial ecology. Removal of individual cougars in higher quality habitats could increase cougar use because a home range vacancy increases the probability of use by multiple individuals, until residency of a single individual is established. The authors argue that a better strategy may be found in improved landscape planning. They describe the relevant features of such an approach, and make recommendations for how human development should be implemented.

Khorozyan I, Waltert M. 2019. A Framework of Most Effective Practices in Protecting Human Assets from Predators. *Human Dimensions of Wildlife* 24(4):380-94. DOI:10.1080/10871209.2019.1619883

Human-caused mortality is the main factor threatening 28 large predators, largely aggravated by perceived and real damage by large predators to human assets (e.g., livestock depredations, crop loss, human safety). In order to mitigate human-predator conflicts and reduce the negative impacts on predators, it is essential to employ best practices in protecting domestic livestock, agricultural crops, and human neighborhoods. This requires the application of non-invasive (i.e., without direct contact with predators) and targeted interventions to promote predator conservation and local livelihoods.

Khorozyan and Waltert compiled 117 cases from 23 countries and quantified the effectiveness of 12 non-invasive interventions designed to protect human assets from 21 predators. They found: a) the most effective interventions were electric fences, guardian animals, calving control, and physical deterrents; b) the most effectively protected asset was livestock; and c) the most effective interventions being used were to protect assets from cheetahs (*Acinonyx jubatus*), Eurasian lynx (*Lynx lynx*), gray wolves (*Canis lupus*), and lions (*Panthera leo*). In all of these cases, the relative risk of damage caused by predators was reduced by 50-100%.

Khorozyan and Waltert propose a framework of best practices combining the most effective interventions, protected assets, and interventions against specific predator species. This framework may serve as a useful guide for land managers, livestock owners, and conservationists in mitigating human-predator conflicts.

Killion AK, Melvin T, Lindquist E, Carter NH. 2018. Tracking a Half Century of Media Reporting on Gray Wolves. *Conservation Biology* 33(3):645-54. DOI: 10.1111/cobi.13225

Understanding public opinions about large carnivores can help wildlife managers better address conservation issues. As public interest influences what the media reports, and the media, in turn, can influence human perceptions of wildlife, analyzing the salience of media reports is one way to assess topics relevant to the public.

Killion et al. quantitatively assessed the salience of topics surrounding the gray wolf (*Canis lupus*), which was reintroduced to Idaho in 1995. The authors analyzed articles published between 1960 and 2015 in an Idaho newspaper, identifying six distinct topics associated with gray wolves: policy, hunting, biological status, implementation of management, recovery, and human-wolf conflict. They identified two turning points in how these topics were being publicly discussed, namely the reintroduction of wolves in 1995 and the delisting of wolves in 2009.

Killion et al. found that articles written by local reporters were more likely to report on topics regarding human-wolf conflicts, while articles sourced from national outlets were more likely to report on wolf policy and biological status. Because media can play an influential role in shaping support for different conservation strategies, identifying how issues are framed can be useful in developing new media relation plans to promote productive dialogue supporting coexistence.

Kinka D, Young JK. 2019. Evaluating Domestic Sheep Survival with Different Breeds of Livestock Guardian Dogs. *Rangeland Ecology & Management*. DOI:10.1016/j.rama.2019.07.002

Livestock guardian dogs (LGDs) have been widely adopted by domestic sheep (*Ovis aries*) producers because they reduce predation by wild carnivores. Originally used in the United States to guard against coyote (*Canis latrans*) depredations, their efficacy against other large carnivores, and whether specific breeds perform better than others, remains unclear.

Kinka and Young assessed breed-specific effectiveness at reducing depredations from a suite of large carnivores in Idaho, Montana, Oregon, and Wyoming by comparing survival rates of sheep protected by various breeds of LGDs. The authors compared the efficacy of the mixed-breed known as "whitedogs," commonly used in the United States, with three novel breeds from Europe. Variations in effectiveness were subtle, but overall they found that Turkish kangals, Bulgarian karakachans, and Portuguese transmontanos are all associated with a reduced hazard of depredation compared with whitedogs. Furthermore, Kangals were associated with a significant reduction in cougar, black bear, and coyote depredations, and karakachans were associated with significant reductions in coyote depredations.

The authors provide empirical evidence regarding the increased aptitude of three purebred LGD breeds for preventing sheep depredation. These findings may help livestock producers and wildlife managers make tailored decisions about how best to incorporate different LGD breeds into sheep grazing regimes.

Kinka D and Young JK. 2018. A Livestock Guardian Dog by Any Other Name: Similar Response to Wolves Across Livestock Guardian Dog Breeds. *Rangeland Ecology and Management* 71(4):509-17. DOI:10.1016/j.rama.2018.03.004

Used to mitigate depredation of livestock, livestock guardian dogs (LGDs) gained popularity in the United States as a nonlethal predator control in the late 1970s when wolves were nearly entirely absent from the landscape. With more than 30 distinct breeds of LGDs found throughout the world, it has been speculated that certain breeds may be more effective at deterring specific threats.

With wolves back on the landscape, Kinka and Young were interested in determining whether the breeds currently in use in the American West may or may not be the best suited for dealing with large carnivores. The authors compared the behaviors of four LGD breeds, all selected for their boldness toward carnivores, history of use in areas with wolves, lack of aggression toward humans, and large size. They also measured the dogs' responses to a simulated encounter with a wolf using a decoy. Although the authors found subtle difference in behavior and predator response between the various LGD breeds, they suggest that LGD behavior is mostly the same across breeds.

Knopff AA, Knopff KH, St. Clair CC. 2016. Tolerance for Cougars Diminished by High Perception of Risk. *Ecology and Society* 21(4):33-41. DOI:10.5751/ES-08933-210433

Low tolerance for cougars in modified landscapes has been identified as a key factor that could restrict continued cougar range expansion in North America, or even reverse some of the gains made by cougar populations in recent decades. To better understand factors influencing tolerance and identify opportunities to improve conservation prospects for cougars, Knopff et al. implemented a questionnaire

in west-central Alberta, where both human and cougar populations have increased over the past 20 years and where they had developed a resource selection function for cougars from telemetry data.

Knopff et al. predicted that tolerance for cougars would be negatively correlated with increased probability of cougar selection near the respondent's home, but that prediction was not supported. Although such correlations have been reported at broader spatial scales, the authors suggest they may break down at finer scales. Other factors, such as education, were important drivers of tolerance for cougars in Alberta.

The authors suggest that education undertaken to improve large carnivore conservation should focus on accurately defining the risks and ecological benefits resulting from maintaining cougars on the landscape. Education may also need to focus on the importance of non-wilderness habitats (i.e., the rapidly expanding backyard) as an important part of long-term conservation and continued range expansion and repatriation of adaptable large carnivores, such as cougars.

Kompaniyets L and Evans MA. 2017. Modeling the Relationship between Wolf Control and Cattle Depredation. *PLoS ONE* 12(10). DOI:10.1371/journal.pone.0187264

Wolf control to reduce cattle depredation is an important ecological and agricultural issue in the United States. Two recent papers, using the same dataset of wolf population characteristics and cattle depredation, came to opposing conclusions concerning the link between wolf control and cattle depredation.

In an effort to resolve the discrepancy, Kompaniyets and Evans drew from the same dataset—specifically wolf population, number of cattle, number of wolves killed, and number of cattle killed, from the U.S. Fish and Wildlife Services Interagency Annual Wolf Reports over the period of 1987-2012—developed a model based on a causal association that would explain the nature of the relationship between wolf control and cattle depredation.

They found a positive correlation between wolf control and cattle depredation. However, they state it would be incorrect to infer that wolf control has a positive effect on the number of cattle depredated. They maintain that this link comes from a growing wolf population, which increases cattle depredation, and in turn, causes an increase in the number of wolves killed. While the wolf population is growing, the authors see both wolf removal and cattle depredation simultaneously growing, and suggest that not until the wolf population growth nears the steady state will removal of wolves have a sufficient negative effect to reduce or stabilize the number of cattle depredated.

Lacher I, Wilkerson ML. 2013. Wildlife Connectivity Approaches and Best Practices in U.S. State Wildlife Action Plans. *Conservation Biology* 00(0):1-9. DOI:10.1111/cobi.12204

As habitat loss and fragmentation threaten biodiversity on large geographic scales, creating and maintaining connectivity of wildlife populations is an increasingly common conservation objective. To assess the progress and success of large-scale connectivity planning, conservation researchers need a set of plans that cover large geographic areas and can be analyzed as a single data set; state wildlife action plans (SWAPs) fulfill these requirements.

Lacher and Wilkerson examined 50 SWAPs to determine the extent to which wildlife connectivity planning, via linkages, is emphasized nationally. They defined linkages as connective land that enables wildlife movement, and identified and quantified keywords and content criteria They found only 30% or less of the SWAPs fulfilled highly specific content criteria. They found positive correlations between their content criteria and statewide data on percent conserved land, total focal species, and spending on parks and recreation.

Lacher and Wilkerson's results reflected nationwide disparities in linkage conservation priorities and highlight the continued need for wildlife linkage planning. The authors suggest some best practices for wildlife linkage conservation plans.

Ladle A, Steenweg R, Shepard B, Boyce M. 2018. The Role of Human Outdoor Recreation in shaping patterns of Grizzly Bear-Black Bear Co-occurrence. *PLoS ONE* 13(2):e0191730.
DOI:10.1371/journal.pone.0191730

Grizzly bear and black bear distribution is influenced by a combination of variables and biotic interactions with each other and other species, including people. These interactions can be altered by anthropogenic factors such as human activity. Human recreational activity is an increasing issue for large predators and has the potential to alter entire ecological communities through redistribution and changes in activity patterns.

Through adapting models for multiple-species occupancy analyses, Ladel et al. analyzed trail camera data from 192 locations in and around Jasper National Park, Canada, to estimate grizzly and black bear occurrence and their use of human-accessed trails, both motorized and non-motorized trails. They determined Grizzly bears were displaced to higher elevations in areas affected by motorized use, while black bears showed higher temporal activity overlap with both motorized and non-motorized recreational activity.

The increasing popularity of off-road motorized recreation in North America is posited to reduce trail use by grizzly bears. Avoidance of trails may affect grizzly bears' ability to forage, negatively influencing recovery opportunities. The authors make the case that these findings should inform policy relating to recreational access and management in grizzly bear habitat.

Lamb C, Mowat G, Reid A, et al. 2018. Effects of Habitat Quality and Access Management on the Density of a Recovering Grizzly Bear Population. *J Appl Ecol.* 55:1406-1417.
DOI:10.1111/1365-2664.13056

As humans gain access to remaining wilderness, increasing human-carnivore overlap is elevating cumulative pressures on carnivore populations. Elevated road densities and human presence in wilderness areas have increased human-caused mortality of grizzly bears and reduced bears' access to effected landscapes. Incursion of roadways into wilderness is causing an observable decline in grizzly bear survivability (Falcucci et al. 2014). However, large-scale carnivore recolonization and human carnivore coexistence are possible in human-dominated landscapes when targeted conservation efforts relieve human pressures on carnivores.

Lamb et al. conducted a spatially explicit capture-recapture study on the provincially threatened Kettle-Granby Grizzly Bear Population Unit in British Columbia, to determine the effect of roads and human disturbance on survivability and spatial distribution. Although a 50% increase in bear density since 1997 was observed, bear density was lower where road densities exceeded 0.6 km/km2 and higher where motorized vehicle access had been restricted.

The authors argue that the negative effects of road densities related to grizzly bear density may be ameliorated when access controls or road removal are implemented to limit human presence. They then suggest a policy target of managing road densities below 0.6km/km2, while ensuring areas of high habitat quality have no roads.

Lamb CT, Mowat G, McLellan BN, Nielsen SC, Boutin S. 2017. Forbidden Fruit: Human Settlement and Abundant Fruit Create an Ecological Trap for an Apex Omnivore. *Journal of Animal Ecology* 86(1):55-65. DOI:10.1111/1365-2656.12589

Animals tend to use a series of cues established over evolutionary time to select habitats that maximize their fitness (Darwin 1859, Fretwell and Lucas 1970). However, maladaptive habitat selection can occur when novel conditions decouple the link between habitat quality and fitness, resulting an in ecological trap or ET (Dwernychuk and Boag 1972). ETs and human activity are often associated because human alteration of landscape tends to occur more rapidly than cues evolve to guide an animal's response to landscape changes (Robertson et al 2013, Hale and Swearer 2015).

Apex consumers are highly vulnerable to ETs because they typically lack natural predators and may not perceive or avoid novel sources of risk such as human predation (Robertson et al. 2013). Lamb et al. tested for an ET for grizzly bears using demographic and movement data collected in an area rich with food resources and concentrated human settlement.

They found that a valley high in both berry resources and human density was more attractive than surrounding areas, and bears occupying this region faced 17% lower apparent survival. Despite lower habitat fitness, they detected a net flow of bears into this ET, which contributed to a study-wide population decline. The authors suggest that this study highlights the presence and pervasiveness of an ET for an apex omnivore that lacks the evolutionary cues, under human-induced rapid ecological change, to assess tradeoffs between food resources and human-caused mortality, which results in maladaptive habitat selection.

Lambert CMS, Wielgus RB, Robinson HS, Katnik DD, Cruickshank HS, Clark R, Almack J. 2006. Cougar population dynamics and viability in the Pacific Northwest. *Journal of Wildlife Management* 70(1):246-54. DOI:10.2193/0022-541X(2006)70[246:CPDAVI]2.0.CO;2.

Increasing reports of human-cougar conflicts may suggest that cougars are increasing in the Pacific Northwest—indeed this is a widely accepted belief. Lambert et al. determined minimum relative densities and average fecundity, survival, and growth rate of a cougar population in northeast Washington, northern Idaho, and southern British Columbia.

Contrary to accepted belief, the authors' findings suggest a declining Pacific Northwest cougar population. They describe their demographic/population findings, and postulate that increasing conflicts

between cougars and humans in this area could be the result of: (a) the very young age structure of the population, caused by heavy hunting; (b) increased human intrusion into cougar habitat; (c) low level of social acceptance of cougars in the area; and/or (d) habituation of cougars to humans.

Lambert et al. reject that cougars are currently increasing in their study area. They suggest that this decline could be reversed by decreasing harvest rates, especially for adult females, and that wildlife managers should not assume that increasing cougar-human complaints correspond with increasing cougar populations. Indeed, increasing complaints may accompany a rapidly declining population as shown in this area. Sustainable hunting regulations and bag limits should not be based on numbers of cougar complaints, but should be based on reliably estimated demographic trends.

Lambert et al. recommend reduced levels of cougar exploitation, particularly for adult females, and upgraded monitoring and collaborative efforts to accurately account for demographic trends.

Lance NJ, Breck SW, Sime C, Callahan P, Shivik JA. 2010. Biological, technical, and social aspects of applying electrified fladry for livestock protection from wolves. *Wildlife Research* 37:708-14. DOI:10.1071/WR10022.

Management of wolf predation on livestock is an adaptive process that ideally uses a suite of tools. Fladry (interspersed flagging suspended on a single strand of rope or twine) is a barrier tool that has been successfully used to deter wolves from approaching livestock. It is a type of primary repellant that relies on producing a flight response. However, wolves do habituate to fladry, which reduces its effectiveness over time. Electrified fladry is a relatively new variation on the traditional design that incorporates an electric shock in order to decrease the potential for habituation. Electrified fladry appears to offer superior protection compared with non-electrified fladry. In testing that utilized captive wolves, Lance et al. found that electrified fladry was 2 to 10 times more effective than fladry for protecting a food resource.

Electrified fladry is also significantly more expensive than fladry. In terms of overall effectiveness at deterring wolves, as well as these economic costs, Lance et al. suggest that electrified fladry may best be applied to smaller pastures and/or targeted to areas prone to persistent conflict.

Nonlethal tools are often criticized for being time and resource intensive, but lethal alternatives have associated criticisms of their own when considering diverse stakeholders and when costs and benefits are defined more broadly. Lance et al. suggest that nonlethal tools like electrified fladry may be essential for fostering and increasing tolerance of predators, especially when used in combination with other lethal and nonlethal tools.

Landon AC, Jacobs MH, Miller CA, Vaske JJ, Williams BD. 2019. Cognitive and Affective Predictors of Illinois Residents' Perceived Risks from Gray Wolves. *Society & Natural Resources.* DOI:10.1080/08941920.2019.1664680

Increasing wolf populations are a concern for wildlife managers in the Midwestern United States. Perceived incongruence between human values and wolves has fueled opposition to their presence in areas of co-habitation, with concerns being raised about livestock depredations, game competition, and public safety. Understanding the psychological mechanisms that contribute to public perceptions of risk

are important for developing strategies that seek to mitigate these risks, and indicate where outreach efforts may facilitate acceptance of wolves.

Landon et al. examined the psychological factors that influence Illinois residents' perceived risks from wolves, including their basic beliefs about wildlife, their attitude toward wolves, and negative affect toward wolves. Although Illinois residents are minimally exposed to wolves, with only 11 individual wolves confirmed in the state since 2002, the authors found perceived risks by residents stem from a subjective evaluation of the costs and benefits of wolves and the emotions they elicit in individuals, rather than an objective cost-benefit analysis. This indicates a need to develop strong communication strategies to provide residents with accurate information about the actual risks associated with wolves, the benefits of wolves on the landscapes, and the appropriate risk-mitigation actions to take.

Laporte I, Muhly TB, Pitt JA, Alexander M, Musiani M. 2010. Effects of Wolves on Elk and Cattle Behaviors: Implications for Livestock Production and Wolf Conservation. *PLoS ONE* 5(8):e11954. DOI:10.1371/journal.pone.0011954

Prey species often exhibit anti-predator behaviors (e.g., increased vigilance, grouping, changes in movement patterns) in the presence of predators. These behaviors and associated stress can be expected to cause negative physiological effects, such as weight loss and reduced reproduction. Livestock depredation compensation programs typically focus on the market value of animals killed outright. One criticism of these models (and a general complaint of livestock producers in relation to expanding predator populations) is the failure to account for less-visible physiological costs associated with anti-predator behaviors. Leaving aside the issue of whether anti-predator behaviors are effective at deterring predation, they may result in increased stress, which may leave cattle more vulnerable to infections and disease, abortion and early birth, as well as weight loss, all of which can have a subtle but negative effect on market values.

Laporte et al. monitored herds of cattle, consisting entirely of yearlings, located on a public land grazing allotment. Collared wolves from four different packs were in the area. Behavioral responses were measured before, during, and after known wolf presence in or near cattle pastures. The authors also monitored elk habitat use in relation to wolf presence.

They authors found that individual cattle increased their path sinuosity and decreased their distance to neighbors. Groups of cattle erratically changed speed, increased head-up time, decreased path sinuosity, and decreased their distance to neighbors. However, less than half of wolf visits to pastures prompted a change in a response variable, with no clear pattern. The data imply that there are energetic costs associated with wolf presence. Since wolves seem to affect cattle, it follows that there might be some fitness costs to the cattle. This may yield economic consequences for ranchers.

Laporte et al. note that domestic prey often show weaker behavioral responses to predators than do wild animals, presumably because of human selection for docility as well as the livestock's unfamiliarity with predators. Cattle groups have shown a number of behavioral changes concomitant to wolf visits. Nonetheless, direct fitness costs have not been quantified alongside behavioral observations. There are no direct data relating anti-predator behaviors to physiological consequences. Similarly, inference on presence and importance of anti-predator behaviors in cattle has to be limited. The behavioral and biological complexity associated with predation is very high, and associated variables are often complex and confounding.

Larson S, McGranahan DA, Timm RM. 2019. The Marin County Livestock Protection Program: 15 Years in Review. *Human-Wildlife Interactions* 13(1):63-78. DOI:10.26076/sxsv-er39

In 2001, Marin County, California, replaced its U.S. Department of Agriculture Wildlife Services cooperative predator damage management program with a county-run program that emphasizes nonlethal methods for carnivore control for preventing domestic sheep (*Ovis aries*) depredations. This new Livestock Protection Program (LPP) cost-shares with livestock producers to improve fencing, obtain guard animals, and initially compensated producers for documented losses of livestock.

In 2016, 15 years into the program, Larson, McGranahan and Timm surveyed sheep producers in Marin County to determine their perceptions of the program, and how their perceptions may have changed since the last time they were surveyed in 2006. They found that producers are generally dissatisfied with the LPP and that predation by coyotes (*Canis latrans*) remains a high concern. The number of sheep producers has declined, and some producers are now grazing less acreage with smaller flocks.

Larson, McGranahan and Timm recommend the compensation program be reinstituted for verified sheep losses, and that funding be available for the employment of a county-based specialist or contracted specialist to respond with professional expertise during critical times, such as lambing season.

Lee T, Good K, Jamieson W, Quinn M, Krishnamurthy A. 2016. Cattle and Carnivore Coexistence in Alberta: The Role of Compensation Programs. *Rangelands* 39(1):10-16. DOI:10.1016/j.rala.2016.11.002

When Large carnivores and cattle come into contact, the resulting interactions can negatively impact ranchers, cattle, and/or the carnivore. Compensation systems are often developed when governments feel an obligation to protect producers from economic losses due to carnivore depredation. These compensation scheme and related conservation efforts are often developed in a top-down manner with limited dialogue between wildlife managers and livestock producers.

Lee at al. analyzed Alberta, Canada's, coexistence strategies for beef producers and carnivores. Specifically, they: estimated economic losses sustained by Alberta's beef producers; assessed the ability of the Wildlife Predator Compensation Program (WPCP) to alleviate costs; and gathered beef producers' opinions regarding the efficacy of the program.

The authors found that a majority (64%) of the survey respondents reported losses from carnivore depredation, with direct annual economic loss to depredations calculated to be $2 million. With further extrapolation through a number of assumptions, results indicated provincial losses of $22 million. Concurrently, the WPCP paid out an average of $220,584 annually from 2011-2013. The authors determined the WPCP to be under-utilized, where 64% of producers did not report to the program, and did not adequately address financial burden experienced by producers from 2011to 2013.

The authors suggest their findings highlight that the current Alberta compensation program is not well utilized, and that estimated losses incurred by beef producers presented are highly conservative and do not represent the total losses of cattle to depredation occurring in Alberta.

Lennox R, Gallagher A, Ritchie E, Cooke S. 2018. Evaluating the Efficacy of Predator Removal in a Conflict-Prone World. *Biological Conservation* 224:277-89. DOI:10.1016/j.biocon.2018.05.003

Predators are often perceived as competitors or threats to human values or wellbeing. This conflict has persisted for centuries, often resulting in predator removal (killing) through targeted culling, trapping, poisoning, and/or public hunts. Predator removal persists as a management strategy but benefit from scientific evaluation to assess the impacts of these as human-carnivore conflicts intensify with predator reintroduction and rewilding alongside expanding human populations.

To assess the efficacy of predator removal, Lennox et al. reviewed literature investigating predator removal and focused on identifying instances of successes and failures. The authors determined previous studies to be retrospective and correlative, with few controlled experimental approaches that evaluated whether predator removal met definitions of success. While inconclusive due to heterogeneity of assessed methodologies, the authors found predator removal to only be effective in the short-term, failing in the absence of sustained, costly predator suppression.

The authors suggest that management must consider the role of the predator within the ecosystem and the potential consequences of removal on competitors and prey. Simulations or models can be generated to predict responses prior to removing predators. They also suggest that alternatives to predator removal be further developed and researched. In conclusion, the authors argue that their findings determined that success in predator removal is highly contextual and should not be assumed by management without rigorous testing.

Lischka ST, Teel TL, Johnson HE, Crooks KR. 2019. Understanding and Managing Human Tolerance for a Large Carnivore in a Residential System. *Biological Conservation* 238.
DOI:10.1016/j.biocon.2019.07.034

Human tolerance for interactions with large carnivores is an important determinant for their persistence on the landscape, yet the relative importance of factors affecting tolerance is not fully understood. Additionally, management efforts to influence tolerance has not been adequately assessed.

Lischka et al. developed a model containing a comprehensive set of predictors for measuring tolerance of black bears (*Ursus americanus*) near Durango, Colorado, with predictors including previous human-bear conflicts, outcomes of interactions with bears, perceptions of benefits and risks from bears, trust in managers, perceived similarity with the goals of managers, personal control over risks, value orientations toward wildlife, and demographic factors. Furthermore, the authors investigated whether a large-scale bear-proofing experiment designed to reduce garbage-related conflicts in the community was successful at increasing tolerance.

Lischka et al. found that more tolerant residents typically perceived greater benefits associated with bears and experienced more positive impacts from bear-related interactions, while residents who were less tolerant tended to be older, hold dominion wildlife values, had greater trust in managers, and perceived greater risks and more negative impacts from bear-related interactions. The bear-proofing experiment did not affect tolerance. These findings suggest that communication approaches aimed at increasing public tolerance could be improved by emphasizing the benefits and positive impacts of living with black bears.

Lopez Bao J, Bruskotter J. 2017. Finding Space for Large Carnivores. *Nature Ecology and Evolution* 1(5):0140. DOI:10.1038/s41559-017-0140

After a long history of persecution, large carnivores are becoming increasingly isolated from humans and restricted to remote wilderness areas. Large carnivores have become emblematic of such protected areas, establishing a precedent that wilderness and remoteness are essential requirements for their conservation. These perceptions often shape the extent of their range in many areas.

Lopez-bao and Bruskotter argue that confining large carnivores to be creatures of wilderness impedes collective ability to envision conservation alternatives that do not include wilderness or remoteness. They suggest the conservation of large carnivores would benefit from a philosophical shift, freeing these species from wilderness and viewing them instead as normal and legitimate parts of human-dominated landscapes. Further, they argue that extending large carnivore conservation approaches beyond the boundaries of wilderness and natural areas into a wider realm where people and large carnivores share the landscape may lead to the outcomes conservation biologists have been striving for since mid-1980s: functional populations of large carnivores that are demographically and genetically viable.

Lopez-Bao J, Chapron G, Treves A. 2017. The Achilles Heel of Participatory Conservation. *Biological Conservation* 212:139-43. DOI:10.1016/j.biocon.2017.06.007

Globally, public participation has become a generalized component of environmental decision- making in forestry, wildlife, or water management and conservation. Although participatory planning for conservation has gained prominence over the past few decades, whether this process is successful in protecting biodiversity is still controversial. Moreover, the initial, constitutive decisions about whom to include in the process may undermine the sometimes implicit goal that non-participants will find the outcomes legitimate and equitable.

Lopez-Bao et al. focus on the effective integration of the broad public interest into decisions on use and preservation of the environment and explore if the broad public interest should be considered a prerequisite to processes that are democratic, legitimate, and equitable.

The authors argue that when narrower interests become entrenched, conservation conflicts can become chronic as opponents take intransigent positions and polarize debate. Further, they suggest participatory decision-making processes could be improved by codifying the democratic principles of intergenerational equity and the public trust doctrine, in addition to inclusion of impartial trustees charged with monitoring and enforcing preservation and regulation of decisions.

Lozano J, Olszanska A, Morales-Reyes Z, Castro AA, Malo AF, Moleón M, Sanchez-Zapata JA, Cortés-Avizanda A, von Wehrden H, Dorresteijn I, Kansky R, Fischer J, Martín-López B. 2019. Human-Carnivore Relations: A Systematic Review. *Biological Conservation* 237:480-92. DOI:10.1016/j.biocon.2019.07.002

Effective carnivore conservation involves interdisciplinary approaches due to the complex and interrelated ecological and social factors that characterize human-carnivore relations. Lozano et al. systematically reviewed the existing research on human-carnivore relations between 2000 and 2016

with the goals to identify key knowledge gaps and future research priorities, as well as to appraise the level of application of interdisciplinary social-ecological approaches.

Lozano et al. found the research to be biased in four ways: 1) more studies have been conducted in the Global North than in the Global South, 2) research is most focused on large carnivores rather than smaller-bodied carnivores, 3) relations were often framed around conflicts, with little attention to possible ecosystem services, and 4) most research was carried out using natural science methods, despite the possible benefit of using methods from the social sciences in this context.

Current research is geographically, taxonomically, and methodologically biased. Addressing these biases and advancing social-ecological research on human-carnivore relations may be helpful in navigating and resolving the real-world challenges of living with carnivores.

Lute ML, Carter N, Lopez-Bao J, Linnell J. 2018. Conservation Professionals Agree on Challenges to Coexisting with Large Carnivores But Not on Solutions. *Biological Conservation* 218:223-32. DOI:10.1016/j.biocon.2017.12.035

Large carnivores are controversial species in the field of wildlife conservation. Their predatory behavior, including killing domestic animals or game species, comes into conflict with human interests and may represent the main factor hindering human-carnivore coexistence. In response to multiple conservation challenges, two fundamental perspectives have been proposed: land sparing for carnivores or land sharing between humans and carnivores. Tension between these two perspectives is evident among conservation professionals working toward coexistence with carnivores. Due to interactions with stakeholders, media, and the general public, the values and perspectives instilled by conservation organizations on this topic are important towards shaping associated conservation policy and practice.

Lute et al. surveyed international conservation practitioners (n=505) on a wide array of questions regarding the conservation and management of large carnivores. The majority of participants agreed people and large carnivores can share the same landscapes (86%) and express acceptance of some conflict (93%), while sharing widespread acceptance of the intrinsic value of carnivores. Results determined polarization of opinions around using lethal control as means of conflict reduction, decreasing population sizes or increasing human tolerance, profits, livelihoods, or fear of humans.

The authors state that these differing viewpoints represent diverse strategies to conserve carnivores, and differing moral platforms relating to what, how, where, and for whom conservation of large carnivores should occur. They argue that challenges to adopting and implementing long-lasting carnivore conservation strategies may occur as much within the conservation community as outside it.

Lute ML, Gore ML. 2014. Knowledge and Power in Wildlife Management. *Journal of Wildlife Management* 78(6):60-68. DOI:10.1002/jwmg.754.

Despite a trend toward more transactional processes that purposefully incorporate stakeholder knowledge, technical and science-based information remain dominant inputs for wildlife governance. Thus, most decision-making rests with wildlife managers and politicians, depends on scientific knowledge, and includes varying involvement of local stakeholders. Resultant tension from top-down wildlife governance can result in conflict over stagnated wildlife management decisions. Understanding

public perceptions of knowledge and power can help improve management effectiveness that balances top-down and bottom-up approaches.

Lute and Gore used Michigan wolf management as a case study to explore this relationship in regard to delisted endangered species. Through semi-structured interviews of highly involved stakeholders, they qualitatively explored public perceptions related to power inequalities among groups, and the role of scientific knowledge in decision-making associated with hunting wolves in Michigan.

Lute and Gore identified emergent themes including sources of knowledge for decision-making; political power overrides science in decision-making; special interests disenfranchise other publics; and mistrust of decision-makers exists among stakeholders. They argue that further testing and validation of these themes could inform predictive models and inferential studies useful for public participant planning and stakeholder engagement.

Lute ML, Gore ML. 2014. Stewardship as a Path to Cooperation? Exploring the Role of Identity in Intergroup Conflict Among Michigan Wolf Stakeholders. *Human Dimensions of Wildlife* 19(3):267-79. DOI:10.1080/10871209.2014.888600.

Disagreement over how to manage human-wildlife conflict is a challenge for contemporary wildlife management. Integrating human dimensions into wildlife management has provided key insights into understanding what and how people think about human-wildlife conflict, not least of which includes measuring concepts such as social acceptance capacity, support for compensation schemes, or media coverage effects (Bruskotter et al. 2007, Mertig 2004, Treves et al. 2009). Yet, some wildlife management actions remain highly controversial among stakeholder groups.

Social identity may cause stakeholders to organize into groups of individuals with similar positions, and identity differences between groups may be driving debate. Understanding group conflict through social identity theory may help inform human-wildlife conflict management and other politically contentious wildlife management issues.

Lute and Gore examined a case study of Michigan wolf management to determine if stewardship—defined as behavioral intensions motivated to benefit wolves or support their management—might help transcend different identities and reorient dialogue toward cooperation.

The authors found that in-group bias can reveal potential underlying factors for conflict over recovered wolf management—interviewees offered mostly negative and one-dimensional stereotypes of out-groups which dichotomized stakeholders into pro-hunting or anti-hunting across contexts. They suggest several methods for bringing stakeholders together including advancing group cooperation through activities aimed at addressing out-group stereotypes, encouraging diverse stakeholders to identify as stewards, and enfranchising groups to collaborate on shared responsibilities to nature.

Lute ML, Navarrete CD, Nelson MP, Gore ML. 2016. Moral Dimensions of Human-Wildlife Conflict. *Conservation Biology* 30(6):1200-11. DOI:10.1111/cobi.12731.

Despite increasing support for conservation globally, controversy over specific conservation policies persists among diverse stakeholders. Investigating the links between morals in relation to conservation

can help increase understanding about why humans support or oppose policy, especially related to human–wildlife conflict or human conflict over wildlife. Yet the moral dimension of human–wildlife conflict has mostly gone unconsidered and unmeasured; thus, policy and programmatic efforts to reduce controversy may be missing a key part of the equation.

Lute et al. conducted a web-based survey in Michigan to investigate cognitive and emotional influences on the value–behavior relationship. Respondents were identified by their interest and involvement in Michigan wolf management. The survey consisted of questions about values, emotions, cognitions, and behaviors relative to wolves in Michigan. The authors used path analysis to explore whether emotions and cognitions mediated the relationship between value and behavior. Most respondents attributed intrinsic value to wolves and all life, and engaged in behaviors that benefited wolf populations and ecosystems regardless of stakeholder group (e.g., environmentalist, farmer).

Attributing intrinsic value to wolves was positively related to favorable emotions toward wolves and cognitive assessments that hunting and trapping of wolves is unacceptable. Despite similarities in attribution of intrinsic value, groups differed in emotions and cognitions about wolf hunting. The authors argue that these differences provide a useful way to predict stakeholder behavior, and that the findings may inform interventions aimed at increasing support for wolf management policies and positive interactions among stakeholders and wildlife. Leveraging agreement over intrinsic value may foster cooperation among stakeholders and garner support for controversial conservation policy.

Madden F. 2007. Creating Coexistence Between Humans and Wildlife: Global Perspectives on Local Efforts to Address Human-Wildlife Conflict. *Human Dimensions of Wildlife* 9:247-57. DOI:10.1080/10871200490505675.

As human populations and development expand, protected areas will increasingly become isolated islands of habitat. Ecosystem-based approaches (dispersal corridors, etc.) have clear value, but conservation efforts in this context hinge on effective integration of the human community. Without properly addressing human-wildlife conflict (HWC), conservation efforts will be hampered by instability and high costs (social and financial).

HWC is often really about human-human conflict, a fact that can hobble conservationists who fail to recognize it. Likewise, biological science does not provide a complete understanding of the conflict or of prospective solutions (precisely because it does not often account for the human dimension). Successful responses to HWC require multiple and adaptive tools, applied in a highly individual and contextual way.

To date, efforts to deal with HWC are chronically hampered by a lack of capacity, in terms of institutional procedures and principles, site-specific processes, policy, effective best-practices tools and approaches, etc. Madden suggests that conservation organizations should functionally recognize the complex, multidisciplinary nature of these conflicts. HWC mitigation efforts also benefit from the implementation of adaptive management and applied research schemes. As always, raw resources (human and financial) are requisite, and support resources need to be identified, developed, and strengthened in ways that attend to the complexity of HWC. In all efforts, collaboration and third-party facilitation are needed to ensure stakeholder engagement.

Madden argues that HWC escalates when people feel that the needs or values of wildlife are given priority over their own needs, and/or when local institutions and people are not adequately equipped to

deal with the conflict. She suggests that establishment of equitable and effective management structures and mitigation processes is of great importance.

Madden F, McQuinn, B. 2014. Conservation's Blind Spot: The Case for Conflict Transformation in Wildlife Conservation. *Biological Conservation* 178: 97-106. DOI: 10.1016/j.biocon.2014.07.015.

As the conservation field moves toward more collaborative governance models of engagement (Ansell and Gash 2008, Leong et al. 2011, Reid et al. 2009), too often the processes used or those who are driving the process fail to recognize or reconcile deep-rooted conflict among stakeholders, which can result in hindered conservation goals. Without thorough analysis of these deeper social conflicts, stakeholder engagement processes often overlook or exacerbate the hidden dimensions of conflict that might, if addressed, create conditions for more sustainable long-term agreements.

Unmanaged or poorly managed conflict, including those between humans and wildlife, represents an increasingly difficult obstacle to effective management and conservation of many species of wildlife (Madde 2004, Michalski et al. 2006, Peterson et al. 2013, Redpath et al. 2013). Limited approaches fail to acknowledge, engage, and respond to the deeper social and psychological dynamics—the social conflicts—between individuals and groups.

Using two case studies—gray wolf recovery in Montana, Idaho, and Wyoming, and the fencing out of elephants in communities in south Africa—Madden and McQuinn illustrate how conservation setbacks often stem from a lack of consideration of the full conflict spectrum and an overemphasis on immediate material and economic factors.

Madden and McQuinn argue that long-term conservation success requires deepening conservationists' capacity and strategies to include responses that seek to understand and address these more elusive social conflicts. They propose a reorientation of conservation's understanding of and approaches for addressing conflict through conservation conflict transformation (CCT)—principles and processes adapted from the field of peacebuilding that strive to positively transform often unseen and destructive social conflicts that underlie many conservation efforts.

Maletzke B, Kertson B, Swanson M, Koehler G, Beausoleil R, Wielgus R, Cooley H. 2017. Cougar Response to a Gradient of Human Development. *Ecosphere* 8(7):e01828. DOI:10.1002/ecs2.1828

As human development for industry and housing continues to expand, ensuring large carnivore persistence within these landscapes will require specific information on how species respond to different levels of and patterns of human development. Maletzke et al. examined collar data, utilization distributions, and county tax parcel data to investigate how the cougar (*Puma concolor*) responds to a gradient of human development in areas of the state of Washington.

The authors were able to determine the thresholds of human development at which cougars were no longer functionally present within a variety of wildland-urban landscapes, with significant differences between thresholds of use between Washington's western and eastern ecoregions. Specifically, cougars in eastern Washington used human-developed areas with housing densities $\leq$76.5 residences/km^2, while cougars in western Washington were observed in densities of <846 residences/km^2.

The different thresholds in development densities is likely due to the clustered development patterns present in western Washington, with greenbelts, forested corridors, and dense maritime vegetation facilitating a higher degree of habitat connectivity. Maletzke et al. contend their findings could provide guidance to wildlife managers, landscape planners, and environmental educators to minimize the impacts of human development on cougars and reduce the potential for human-wildlife conflict.

Manfredo M, Teel L, Sullivan L, Dietsch A. 2017. Values, Trust, and Cultural Backlash in Conservation Governance: The Case of Wildlife Management in the United States. *Biological Conservation* 214:303-11. DOI:10.1016/j.biocon.2017.07.032

Research documenting wildlife values in the United States indicates a gradual shift from traditional domination to mutualism orientations (Manfredo et al. 2009). Yet, global populist trends have been explained through the phenomenon of cultural backlash, wherein those left behind in the value shifts start to mobilize to protect their core values and traditions.

Manfredo et al. looked for indicators of cultural backlash from the American hunting culture toward mutualistic values with wildlife that may be associated with recent populist shifts. Data from a 19-state survey (n= 12,673) revealed that, in states with a higher prevalence of mutualism, residents with domination (i.e., traditional) values had lower levels of trust in the state wildlife agencies. Additionally, the authors found evidence of traditional groups' actions to reject and fight back against change, expressed in increases in ballot initiatives from 1990 to 2006 to protect hunting rights.

The authors make the case that backlash will be a global force with important implications for conservation governance. As a result of cultural backlash against mutualism in the U.S., the authors further argue that management agencies will be challenged to incorporate segmented perspectives together into an overall vision for conservation that is broadly inclusive of a full range of wildlife values.

Mattson DJ, Byrd KL, Rutherford MB, Brown SR, Clark TW. 2006. Finding Common Ground in Large Carnivore Conservation: Mapping Contending Perspectives. *Environmental Science and Policy* 9:392-405. DOI:10.1016/j.envsci.2006.01.005

Reducing conflict over large carnivore conservation requires understanding the values, beliefs, and demands of those who are involved. Large carnivores are potent symbols, and symbolic politics is central to many interactions about them. Unclear policy, uncertain information, and diverse and strongly felt demands have provided ample impetus for conflict among stakeholders. Competing definitions of the problem are often contradictory and are tightly linked with perceived solutions.

Mattson et al. conducted a workshop attended by diverse participants involved in large carnivore conservation in the northern Rocky Mountains, and used Q methodology to elucidate participant perspectives regarding problems and solutions. The authors sorted and analyzed their participants' statements and orientations, dividing participants into a number of different groups—e.g. carnivore advocates and devolution advocates—corresponding to their overall stance and viewpoints.

Mattson et al. suggest themes for productive and ameliorative discussion among these otherwise divergent stakeholder groups; notably, all participants recognized (or tolerated) the need for respectful, persuasive, and creative processes that would build understanding and tolerance.

Mattson DJ, Logan K, Sweanor L. 2011. Factors Governing Risk of Cougar Attacks on Humans. *Human-Wildlife Interactions* 5(1):135-58.

Since the 1980s, wildlife managers have expressed increasing concern about the physical threat posed by cougars to humans. Reports document rising numbers of problematic encounters, especially during the 1990s and 2000s (Wakeling 2003, Barber 2005). Of perhaps greatest relevance is the numbers of confirmed attacks by cougars on humans; resulting human fatalities increased by 4- to 5-fold between the 1970s and 1990s (Sweanor and Logan 2010).

Using an analytic framework and multivariable logistic regression models to describe the risk of cougar-caused human injury or death, Mattson et al. analyzed 386 human-cougar encounters and determined that human and cougar behaviors and other factors surrounding cougar-human encounters are complex, and inferring causation can be challenging.

The authors provided a variety of correlations and relationships relating to cougar behavior and human actions, including fatality rates related to cougar age; use of firearms; presence of children and/or dogs; and aggressive human response to the cougar. They suggest that an important result of their investigations was to highlight the comparative rarity of deadly cougar attacks. Nonetheless, awareness of what conditions and behaviors predispose for deadly encounters can be useful to wildlife managers

Mattson DJ, Ruther EJ. 2012. Explaining Puma-Related Behaviors and Behavioral Intentions among Northern Arizona Residents. *Human Dimensions of Wildlife* 17(2):91-111.

Puma management is characterized by stakeholder conflict fueled in part by peoples' responses to puma attacks and their perceptions of how puma predation affects huntable ungulates like deer and bighorn sheep. The policy process is typified by litigation, ballot initiatives, inflammatory incidents, and public incivility. Disagreements often focus on lethal management methods. Widespread trends toward biocentric or mutualist perspectives have changed and diversified people's demands regarding wildlife management outcomes, in stark contrast to historical demands based on utilitarian views, which shaped the cultures of most wildlife management agencies.

Mattson and Ruther assessed demographics, nature-views, puma-related experiences and behaviors, as well as support for various puma-related policies, among residents of Northern Arizona. Results clearly demonstrated that nature-views are superior to demographics in explaining (statistically and otherwise) the behaviors and perceptions of people who hold pronounced views on puma management. Of the variety of nature views that the authors describe, Utilitarian/Dominionistic (U/D) views seem to be the primary determinant of how people orient to pumas and puma policies. The strength of this U/D nature-view largely determines how people perceive lethal practices and policies. The U/D view was unambiguously and consistently identified with behaviors and policies that featured killing or opposition to policies that would limit killing. The U/D nature-view is very strongly related to support for lethal practices, which are the norm of current puma management.

Although hunting was strongly identified with U/D views, U/D views did not translate into support for protecting habitat to benefit pumas. Mattson and Ruther hypothesize that those with strong U/D views are inclined to see pumas as competitors for ungulate hunting opportunities, rather than as creatures of intrinsic value. The authors suggest that educating people about pumas will not have much effect on how they behave when around pumas or what kinds of puma management they would support.

Miller JRB. 2015. Mapping Attack Hotspots to Mitigate Human-Carnivore Conflict: Approaches and Applications of Spatial Predation Risk Modeling. *Biodivers Conserv* 24(12):2887-911. DOI:10.1007/s10531-015-0993-6.

Though cost-efficient nonlethal techniques exist for reducing carnivore attacks (McManus et al. 2014, Lichtenfeld et al. 2014), these tools are often time intensive and difficult to implement across the expansive landscapes where carnivores and livestock interact (Shivik 2006). As a result, many livestock owners continue to use lethal measures to reduce carnivore attacks (Ogada et al. 2003, Inskip et al. 2013), contributing to rapid carnivore population declines and loss of attendant ecosystem service values for humans (Ripple et al. 2014). However, a spatial statistical approach known as predation risk modeling that identifies high priority conflict hotspots where carnivores are likely to attack livestock is rapidly emerging as a tool for informing livestock management and carnivore conservation.

Miller evaluate the approaches and applications of spatial risk modeling for reducing human-carnivore conflict and presented a workflow to help conservation practitioners use this tool. She suggests a need for future predation risk modeling to focus more on validating models, accounting for feedbacks, and impacting conflict-related policy in order to reliably improve the mitigation of human-carnivore conflict globally.

Miller JRB, Stoner KJ, Cejtin MR, Meyer TK, Middleton AD, Schmitz OJ. 2016. Effectiveness of Contemporary Techniques for Reducing Livestock Depredations by Large Carnivores. *Wildlife Society Bulletin* 40(4):806-15. DOI:10.1002/wsb.720.

Mitigation of large carnivore depredation is essential to increasing stakeholder support for human–carnivore coexistence. Lethal and nonlethal techniques are implemented by managers, livestock producers, and other stakeholders to reduce livestock depredations by large carnivores. However, information regarding the relative effectiveness of techniques commonly used to reduce livestock depredations is currently lacking.

Miller et al. evaluated 66 published, peer-reviewed research papers that quantitatively measured livestock depredation before and after employing four categories of lethal and nonlethal mitigation techniques (livestock husbandry, predator deterrents and removal, and indirect management of land or wild prey) to assess their relative effectiveness as livestock protection strategies. Effectiveness of each technique was measured as the reported percent change in livestock losses. Husbandry and deterrents demonstrated the greatest potential but also the widest variability in effectiveness in reducing livestock losses. Removal of large carnivores never achieved 100% effectiveness but exhibited the lowest variation.

Although explicit measures of effectiveness were not reported for indirect management, livestock depredations commonly decreased with sparser and greater distances from vegetation cover, at greater distances from protected areas, and in areas with greater wild prey abundance. Information on time duration of effects was available only for deterrents; a tradeoff existed between the effectiveness of tools and the length of time a tool remained effective.

The authors' assessment revealed numerous sources of bias regarding the effectiveness of techniques as reported in the peer-reviewed literature, including a lack of replication across species and geographic regions, a focus on Canid carnivores in the United States, Europe, and Africa, and a publication bias

toward studies reporting positive effects. Given these limitations, they encourage managers and conservationists to work with livestock producers to more consistently and quantitatively measure and report the impacts of mitigation techniques under a wider range of environmental, economic, and sociological conditions

Milligan S, Brown L, Hobson D, Frame P, Stenhouse G. 2018. Factors Affecting the Success of Grizzly Bear Translocations. *Journal of Wildlife Management* 82(3):519-30. DOI:10.1002/jwmg.21410

As human populations continue to expand into remaining wildlife habitat, recurring and, in some cases, increasing conflict is expected to intensify the need for human-mediated movement of wildlife. Human-mediated wildlife movement is a management tool used for reintroduction, assisted migration, population control, and human-wildlife conflict management. To understand the efficacy of translocation, biological, and behavioral measures of translocated individuals must be compared against baseline data to effectively assess the outcome of translocations.

Milligan et al. evaluated grizzly bear translocations in Alberta to identify the factors contributing to translocation success, and to compare the movement, habitat selection, and denning behavior of translocated and resident grizzly bears to assess the ability of translocated bears to acclimate to their release area. Comparing the home range size, habitat selection, and denning behavior of translocated bears to the resident population over time to assess the long-term effects of translocation, the authors found that the odds of translocation success were higher if bears were moved early in the year, and decreased by 47% for each unit increase in the level of mortality risk (based on road density, water, and edge features) at the release site.

The authors suggest that translocation success is more dependent on release site characteristics than on management factors or the individual characteristics of the bear. Further, the authors advise managers to move bears earlier in the year and release them in areas of low mortality risk (e.g., low road density) and in proximity to a river paired with continued monitoring to improve odds of translocation success.

Morehouse A, Boyce MS. 2011. From Venison to Beef: Seasonal Changes in Wolf Diet Composition in a Livestock Grazing Landscape. *Frontiers in Ecology and the Environment* 9(8):440-45. DOI:10.1890/100172

Wild ungulates are the primary prey for wolves in North America, but livestock predation is a concern in areas where wolves and livestock overlap. Using clusters of global positioning system telemetry relocations and scat analysis, Morehouse and Boyce investigated wolf diets year-round in southwestern Alberta, where seasonal cattle grazing is the predominant land use and wolf-cattle conflicts have increased in recent years.

Morehouse and Boyce found that data from kill-site visitation and scat analysis offered congruent results, indicating a seasonal shift in wolf diets from wild prey during the non-grazing season to cattle during in the grazing season. The authors highlight that boneyards are a growing problem in SW Alberta, and have become more prevalent since the detection of bovine spongiform encephalopathy. Prior to this, rendering trucks often removed dead animals free of charge to be used in dog-food and cattle feed supplements. Government prohibitions have largely curtailed that practice.

The authors recommend development of alternative sanitary disposal methods for dead livestock, in order to prevent wolves from becoming accustomed to feeding on cattle. They suggest that this and other preventative measures will be important components of management plans aimed at reducing predation on cattle. This will be exceptionally critical in areas such as SW Alberta, where 3% of the Province's land area accounts for 37% of paid predator compensation claims. Localized efforts, targeted at these areas, will maximize cost-effectiveness.

Morehouse A, Boyce M. 2017. Troublemaking Carnivores: Conflicts with Humans in a Diverse Assemblage of Large Carnivores. *Ecology and Society* 22(3):4. DOI:10.5751/ES-09415-220304

Carnivores are a flagship conservation species and add intrinsic value to landscapes for some people. However, large carnivores also pose many real and perceived threats to people and communities that live within carnivore home ranges. Carnivores can kill livestock and pets, cause property damage, affect cattle weight gain, and pose a risk to human safety. Responding to carnivore conflicts in multi-predator systems present added complexity, for mitigation strategies are often species specific. Accurate documentation of human-wildlife conflict patterns helps target conflict resolution and provides a baseline against which to measure future conflict mitigation program success.

Morehouse and Boyce evaluated the temporal and spatial distribution of 16 years of conflict complaints among two species of strict carnivores—wolves and cougars—and two species of omnivores—grizzly bears and black bears—in southwestern Alberta, Canada. They determined that conflicts were most frequently associated with bears (68.7% of complaint records) relating to both issues with attractants including grain, dead livestock, and trashcans, and with livestock depredations. In contrast, wolf and cougar incidents were almost exclusively related to killing or injury of livestock.

The authors state that resolving large carnivore-human conflicts is a problem beyond the scope of biology. Successful mitigation programs will integrate concepts from biology, ecology, economics, agricultural sciences, rangeland ecology, sociology, and anthropology both in program design and evaluation. Although community driven, targeted mitigation measures have helped reduce conflicts with grizzly bears at the site level, conflicts at the broader scale have continued to increase and continued work is necessary. Long-term human-carnivore coexistence is possible, facilitated by continued monitoring and local efforts to mitigate conflict couples with landscape-scales funding mechanisms and oversight.

Morehouse AT, Graves TA, Mickle N, Boyce MS. 2016. Nature vs. Nurture: Evidence for Social Learning of Conflict Behavior in Grizzly Bears. *PLoS ONE*. DOI:10.1371/journal.pone.0165425

As grizzly bear populations expand their distribution from the high mountains after removal from much of their historic range (27 28 29), they increasingly overlap with human-settled lands where they are more likely to come into conflict with human land uses such as agriculture and ranching (30, 31, 32). Understanding how bears acquire conflict behavior can have important management implications, especially where conflicts limit public support.

Morehouse et al. evaluated evidence for social learning and genetic inheritance of conflict behavior in grizzly bears in southwestern Alberta, Canada. Using a parentage analysis, they tested the propensity for

grizzly bear offspring to develop conflict behaviors as a result of learning between mothers and cubs, genetic inheritance, or both learning and inheritance.

The authors found that offspring of problem mothers were more likely to be involved in conflict behaviors, while offspring of non-problem mothers were not likely to be involved in incidents or human-bear conflicts. There was no evidence that offspring were more likely to be involved in conflict behavior if their fathers had been problem bears. They suggest that proactive mitigation to prevent female bears from becoming problem individuals may help prevent perpetuation of conflicts through social learning.

Morehouse AT, Tigner J, Boyce MS. 2018. Coexistence with Large Carnivores Supported by a Predator-Compensation Program. *Environmental Management* 61(5):719-31. DOI:10.1007/s00267-017-0994-1

Compensation programs that reimburse producers for damages or losses of livestock due to carnivore depredations are a way to offset the economic loss caused by large carnivores. Risk to human safety and loss of property often lead to lethal control of wildlife, and compensation programs, though hardly a one-size-fits-all solution, can increase tolerance for large carnivores.

Morehouse et al. evaluated the patterns of livestock depredation and compensation costs of Alberta's predator-compensation program, and compared it to programs in neighboring jurisdictions. Alberta's current compensation program is administered by the Alberta Conservation Association (ACA), and is funded by a levy placed on the sale of hunting and sport-fishing licenses (52%) and, as of 2014, by the federal government through the Growing Forward 2 agreement (48%). The authors identified a marked increase in recent years in compensation costs due to elevated cases of depredations and rising cattle prices. While only 0.98%–3.6% of revenue generated by the sale of hunting and fishing licenses was spent on predator compensation between 2001 and 2016, the hunting and fishing community expresses a growing resentment that compensation costs fall almost exclusively on them.

The authors suggest that distributing the costs among various organizations could help to ensure long-term sustainability of compensation programs. Furthermore, their data show that the same private ranch lands with livestock depredation problems also have the highest ungulate hunting efforts, indicating that intact private lands provide important habitat for wildlife populations. Supporting the maintenance of habitat on private lands is important for broader conservation strategies.

Moreira-Arce D, Ugarte CS, Zorondo-Rodríguez F, Simonetti JA. 2018. Management Tools to Reduce Carnivore-Livestock Conflicts: Current Gap and Future Challenges. *Rangeland Ecology and Management* 71(3):389-94. DOI:10.1016/j.rama.2018.02.005

Predation on domestic animals by carnivores is a persistent problem wherever carnivores and livestock co-occur. A wide range of management tools has been used to reduce predation; however, the evidence of their effectiveness remains limited for a broader range of species and conditions.

Moreira-Arce et al. assessed the effectiveness of lethal and non-lethal management techniques for reducing livestock depredation by carnivores. The authors examined 291 cases of depredation from 1990 to 2017 involving a variety of management techniques including lethal control, livestock fencing, livestock guardian dogs, human herders, night confinement, reliance on predation risk models, carnivore

translocation, and aversive devices. The cases involved a wide range of domestic animals and terrestrial carnivores.

The authors suggest that lethal control has no long-term effect in reducing animal predation by carnivores when compared to nonlethal techniques such as livestock guardian dogs, fencing, and the use of herders. They acknowledge that producers' perceptions on the success of different management techniques is crucial for them becoming adopted; if the utilization of nonlethal methods is not only demonstrated but also perceived to effectively decrease predation, the willingness of producers to utilize these techniques will likely increase.

Moss WE, Alldredge MW, Pauli JN. 2016. Quantifying Risk and Resource Use for a Large Carnivore in and Expanding Urban-Wildlife Interface. *Journal of Applied Ecology* 53:371-78. DOI:10.1111/1365-2664-12563.

Large carnivores, though globally threatened, are increasingly using developed landscapes. However, most of our knowledge of their ecology is derived from studies in wildland systems; thus, for effective conservation and management, there is a need to understand their behavioral plasticity and risk of mortality in more developed landscapes.

Moss et al. examined cougar foraging ecology and survival in an expanding urban-wildland system in Colorado from 2007 to 2013. For GPS-collared individuals, they related diet to age-sex class and fine-scale space use, with regard to levels of habitat development. They also examined how habitat development impacted risk of mortality, using hazards models and records of cougar-human conflict.

The authors found that cougars obtained most of their assimilated biomass from native herbivores, and adult females consistently showed higher use of native herbivores than other age-sex classes. Individuals using the most highly developed areas obtained approximately 20% more of their diet from alternative prey (synanthropic wildlife and domestic species) than those in the least developed areas. Overall, survival of adult females was higher than adult males. Yet, use of developed areas substantially increased cougar risk of mortality.

Moss et al. found that cougars showed flexibility in diet, taking advantage of human associated prey items, but had high rates of mortality, suggesting that human tolerance, rather than adaptability, may be the limiting factor for range expansion by cougar and other large carnivores. They argue that large carnivore conservation will not only depend upon adequate prey resources, but also limiting potential conflict resulting from depredation of synanthropic wildlife and domestic animals.

Much R, Breck S, Lance N, Callahan P. 2018. An Ounce of Prevention: Quantifying the Effects of Non-Lethal Tools on Wolf Behavior. *Applied Animal Behavior Sciences* 203:73-80. DOI:10.1016/j.applanim.2018.02.012

Human-carnivore conflict is presently on the rise as human populations continue to grow and carnivore conservation efforts gain precedence. Often carnivores learn behaviors that allow them to access human resources and cause conflict. Consequently, reducing learning potential though the use of nonlethal tools is important for coexistence.

Much et al. measured how prior experience (i.e., conditioning) influenced the motivation and persistence of captive wolves seeking a food reward by quantifying latency to first behavior and duration of behavior for two behavior groups: investigative and work behaviors. Results demonstrated wolves that attained food rewards from an object (i.e., conditioned) showed greater proclivity for future exploration of that object and reduced neophobic behaviors. In particular, results indicated that conditioned wolves were faster to initiate both investigative and work behaviors than non-conditioned animals.

The authors suggest that these results indicate nonlethal tools preventing animals from attaining anthropogenic food can effectively curb learning in carnivores and help reduce human-carnivore conflict. These findings provide evidence that prevention measures are important for the nonlethal management of carnivores and reinforce a fundamental tenant of using nonlethal tools proactively before conflict occurs, as well as reactively when prevention measures can effectively exclude carnivores from attaining future rewards.

Muhly TB, Dubois M. 2013. Advancing the Management of Carnivore Predation on Livestock in Western Canada. *Human Dimensions of Wildlife* 18(4):312-314. DOI:10.1080/10871209.2013.796540

Currently, financial compensation for livestock losses and lethal control of carnivores are the most common tools for addressing livestock predation by carnivores in western Canada (Musiani and Paquet 2004, Treves and Naughton-Treves 2005). However, there is decreasing acceptance by the general public for lethal control (Kellert et al. 1996, Treves and Naughton-Treves 2005), and compensation programs have generally proven to be ineffective at reducing long-term conflict because they fail to prevent future predation (Boitani et al. 2010) or address social factors related to livestock predation conflict (Dickman 2010, Naughton-Treves et al. 2003).

Muhly and Dubois collected from government management agencies and livestock production organizations perceptions of the importance and effectiveness of, and suggested improvements to, management of livestock predation by carnivores in western Canada.

Livestock predation ranked as a top-five priority issue for all those interviewed, and included associated issues related to stable funding and staff; greater agency participation; interest in group engagement; and need for better data. Muhly and Dubois found that compensation programs and lethal control of carnivores are both generally considered ineffective and controversial at reducing conflict. Conversely, subsidizing tools that proactively prevent predation were found to increase positive attitudes toward carnivores (Karlsson and Sjostrom 2011). Increased funding and public/stakeholder engagement strategies such as Adaptive co-management were recommended.

Muhly, TB., Musiani, M. 2009. Livestock Depredation by Wolves and the Ranching Economy in the Northwestern U.S. *Ecological Economics* 68: 2439-50. DOI:10.1016/j.ecolecon.2009.04.008

Because of depredation of livestock by wolves, some groups and individuals oppose wolf conservation in the Northwestern United States. Depredation can have significant monetary costs and cause emotional stress for individual livestock producers, which creates conflict between producers, wolves, and organizations involved in wolf conservation and management.

Compensation is the main tool used to mitigate the costs of depredation; however, this tool does not generally increase tolerance for wolves. Livestock production may in fact indirectly provide an important benefit for wolf conservation by maintaining relatively intact habitat on private lands.
Muhly and Musiani investigated patterns and trends in livestock depredation by wolves, compensation for depredation, and livestock and land price in Idaho, Montana, and Wyoming from 1987 to 2003. They analyzed some of the costs of livestock depredation by wolves relative to recent economic trends in the livestock production industry; specifically income generated from livestock production and trends in land and livestock value.

The authors found that instigation of attacks on livestock by wolves was determined by need for food, but wolves may kill sheep in excess of food needs, which may contribute significantly to intolerance for wolves. Muhly and Musiani report that livestock killed by wolves cost producers approximately $11,076.49 per year between 1987 and 200 and each year these costs accounted for less than 0.01% of the annual gross income from livestock operations. They conclude that wolf depredation is a relatively small economic cost to the industry, although it may be a significant cost to affected producers, as these costs are not equitably distributed across the industry.

Muhly and Musiani suggest that conservation groups should consider the potential consequences of all of these economic trends. Declining cattle prices and the steady increase in land price might prompt conversion of agricultural land onto residential developments, which could negatively impact wolf conservation through large-scale habitat change and increased human presence.

Murray MH, Fassina S, Hopkins JB, Whittington J, St. Clair CC. 2017. Seasonal and Individual Variation in the Use of Rail-Associated Food Attractants by Grizzly Bears (*Ursus arctos*) in a National Park. PLoS ONE 12(5):e0175658. doi.org/10.1271/journal.pone.0175658

The negative effects of roads on wildlife movement and survival are well-documented, but few studies have examined the effects of railways on wildlife. Like roads, railways are efficient transportation systems that degrade or fragment wildlife habitat, impede or facilitate animal movements, and are sites where wildlife mortality occurs through train-wildlife collisions. Although traffic volume is lower on railways than roads, the per-vehicle rate of collisions and mortality can be much higher for trains because they cannot steer around animals on tracks, are more massive and take longer to stop, and often occur in less-disturbed landscapes

Despite the prevalence of this mortality worldwide, little is known about the relative importance of wildlife attractants associated with railways, including spilled agricultural products, enhanced vegetation, invertebrates, and carcasses of rail-killed ungulates. Murray et al. assessed the relative importance of several railway attractants to a provincially threatened population of grizzly bears in Banff and Yoho National Parks, Canada, for which rail-caused mortality has increased in recent decades without known cause. They examined the relationship between the use of the railway and diet by fitting 21 grizzly bears with GPS collars and measuring the stable isotope values derived from their hair. They also examined the importance of rail-associated foods to grizzly bears by analyzing 230 grizzly bear scats, some of which could be attributed to GPS-collared bears.

The authors found no significant relationships between stable isotope values measured from the hair of grizzlies and their frequency of rail use. All four bears that used the railway frequently produced scats containing grain. Almost half the scats collected within 150 m of the railway contained grain compared

to only 7% of scats found >150 m from the railway. Scats deposited near the rail were also more likely to contain grain in the fall than the summer and spring, and those containing grain were more diverse in their contents. Lastly, scats collected near the rail were more likely to contain ungulate hair and ant remains, especially in the summer.

Murray et al. state that their research results support local management knowledge that some bears in the region use the railway to forage and supplement their diets with spilled grain, but that individual use of the railway and associated foods were highly variable. The authors suggest that managers continue to reduce the risk of bears being killed by trains by reactively removing grain and ungulate carcasses from the railway, reducing the amount of grain spilled by trains, and targeting mitigation to the specific individuals and locations that attract recurrent rail-based foraging.

Musiani M, Mamo C, Biotani L, Callaghan C, Gates CC, Mattei L, Visalberghi E, Breck S, Volpi G. 2003. Wolf Depredation Trends and the Use of Fladry Barriers to Protect Livestock in Western North America. *Conservation Biology* 17(6):1538-47.

There are limited cost-effective nonlethal techniques available for managing predation risk from wolves. Many of these tools can be expensive, difficult to maintain, or provide only temporary relief from depredation. Musiani et al. tested the effectiveness of fladry barriers in a number of settings, observing captive and wild wolves in conjunction with bait as well as ranging cattle. They observed that fladry barriers prevented captive wolves from accessing food for up to 28 hours; that wolves approached fladry barriers on 23 occasions but did not cross them; and that no cattle were killed. Wolves killed cattle on neighboring ranches during the trials and before and after the trials on the tested ranches.

Although wolves tended to avoid fladry, they continued to investigate the barrier throughout observed trials, presumably testing the structure for opportunities to cross. The authors could not isolate fear of novelty/habituation as a factor in their study, and did not rule out that their presence monitoring the fladry barriers may have exerted an effect on some of the trials.

Musiani et al. speculate that presence of available prey outside a fladry boundary is critical for enhancing its effectiveness. Also, that fladry may be much less effective when applied on large properties and/or on several contiguous pastures. They suggest that fladry may be most effective to temporarily protect livestock from wolves when livestock is kept in small pastures, such as is done for calving, lambing, overnight holding, or rotational grazing. The authors suggest that fladry can indeed be a very effective tool for deterring wolves in this context. It is simply important to know when and where it will be most effective, as opposed to an alternative option.

Musiani M, Muhly T, Gates CC, Callaghan C, Smith ME, Tosoni E. 2005. Seasonality and Reoccurrence of Depredation and Wolf Control in Western North America. *Wildlife Society Bulletin* 33(30):876-87.

Wolf depredation and control follow a reoccurring seasonal-annual pattern in Alberta and the northwestern U.S. These patterns reflect husbandry practices including the seasonality of livestock calving and grazing practices, as well as seasonal variation in the energetic requirements of wolf packs.

Musiani et al. gathered data from wolf depredation investigations in Alberta, Idaho, Montana, and Wyoming from 1987 to 2003. They analyzed temporal trends in wolf depredation occurrence and wolf control employed as a management action.

Seasonal wolf attacks on livestock were auto-correlated with lags of one year, indicating annual re-occurrence. Cross-correlation analyses indicated that limited wolf control was rapidly employed as a short-term response to depredation, but did not seem to decrease wolf depredation at regional scales or in the long-term.

The authors suggest that ranchers and managers focus their investment of resources on preventative tools during high-depredation seasons and/or locations. Likewise, they advocate for a better understanding of factors predispose for depredation (and subsequent wolf control actions), to allow better anticipation of problems and efficient targeting of conflict management resources.

Naughton-Treves L, Grossberg R, Treves A. 2003. Paying for tolerance: Rural Citizens' Attitudes Toward Wolf Depredation and Compensation. *Conservation Biology* 17(6)1500-11.

As wolf populations recover in Wisconsin, their depredations on livestock, pets, and hunting dogs have increased. Naughton-Treves et al. used a mail-back survey to assess rural Wisconsin citizens' tolerance for wolves, as well as their preferences for managing problem wolves. They assessed tolerance via proxy factors related to preferred wolf population size, likelihood that a person would shoot a wolf, etc. Individuals' approval of lethal control and other management tactics were gauged using five hypothetical conflict scenarios.

The authors found moderate support for wolf recovery in Wisconsin, although 85% percent of respondents wanted a cap placed on the state's population. There were mixed reactions to lethal control, although respondents exhibited fairly strong acceptance of lethal methods.

Not surprisingly, multivariate analysis revealed that the strongest predictor of tolerance was social group. This was more significant than personal exposure or experience with wolves. To a lesser degree, education level, experience of loss (livestock, pets) to wolves, and gender were also significant. Stockmen and hunters who had received compensation for their losses to wolves were *not* more tolerant than their counterparts who alleged a loss but received no compensation, yet all respondents approved of compensation payments as a management strategy. The authors suggest that deep-rooted social identity and occupation are much more powerful predictors of wolf tolerance than direct individual experience with them.

Nelson AA, Kauffman MJ, Middleton AD, Jimenez MD, McWhirter DE, Barber J, Gerow K. 2012. Elk Migration Patterns and Human Activity Influence Wolf Habitat Use in the Greater Yellowstone Ecosystem. *Ecological Applications* 22(8):2293–307. DOI:10.1890/11-1829.1.

Nelson et al. evaluated the influence of elk distribution on wolf habitat use in an area of chronic wolf-livestock conflict in the Greater Yellowstone Ecosystem. Using three years of fine-scale wolf and elk movement data, they compared the seasonal habitat use of wolves in an area dominated by migratory elk with that of wolves in an adjacent area dominated by resident elk.

Although wolves in both areas used elk-rich habitat all year, elk density in summer had a weaker influence on the habitat use of wolves in the migratory elk area than the resident elk area. In the summer, wolves in both prey areas showed use of low- elevation habitats, probably because they only occasionally used high-elevation habitat with elk, but spent more time at moderate elevations close to their home sites. In winter, wolves in the migratory elk area used habitat close to roads, while wolves in the resident elk area avoided roads. In summer, wolves in the migratory elk area were indifferent to roads, while wolves in resident elk areas strongly avoided roads, presumably due to the location of dens and summering elk combined with different traffic levels.

Unexpectedly, the difference in influence of elk on wolf habitat use between summer and winter was much greater among wolves in the resident elk area than the migratory elk area. Extraterritorial forays and rendezvous site shifts seem to allow wolves to track migrating elk relatively well, largely explaining the unexpectedly consistent use of prey-rich habitat.

The results imply that wolves frequent human-dominated areas to a greater degree when high prey density provides a strong incentive; and, where prey exist close to humans, wolves reduce their risk of human-caused mortality by increasing their nocturnal behavior. Even in the face of high rates of lethal removal, wolves will continue to be attracted to—and even intermittently productive within—these front-country landscapes with abundant resident elk populations.

Nelson AA, Kauffman MJ, Middleton AD, Jimenez MD, McWhirter DE, Gerow K. 2016. Native Prey Distribution and Migration Mediates Wolf (*Canis lupus*) Predation on Domestic Livestock in Greater Yellowstone Ecosystem. *Canadian Journal of Zoology* 94(4):291-99. DOI:10.1139/cjz-2015-0094.

Little research has evaluated how the migration and distribution of native prey influence patterns of livestock depredation by large carnivores. Previous research suggests that the presence of native prey can increase depredation rates by attracting predators (prey tracking hypothesis). Alternatively, the absence of native prey may facilitate predation on livestock (prey scarcity hypothesis).

Nelson et al. evaluated support for these competing hypotheses through analysis of 4 years of cattle depredation data, 2 years of summer and fall wolf predation and tracking data, and 3 years of elk movement data. The authors compared the relative influence of landscape features and elk distribution on the risk of livestock depredation in areas with migratory and resident elk.

The authors found that cattle depredations occurred in habitats with increased encounter rates between wolves and livestock. In resident elk areas, depredation sites were associated with elk distribution and open roads. In migratory elk areas, depredation sites were associated with wolf dens, streams, and open habitat. Nelson et al. argue that patterns of carnivore–livestock conflicts are complex, and using ungulate distribution data can predict and minimize such instances.

Nie MA. 2001. The Sociopolitical Dimensions of Wolf Management and Restoration in the United States. *Research in Human Ecology* 8(1):1-12.

Those immersed in wolf politics and policy will recognize that orderly techno-rational and scientific approaches are usually overly simplistic precisely because they don't really attend to issues such as:

community and conceptions of public interest; culture and socialization; myths and images; how information is interpreted, imperfect, framed, and strategically manipulated; and how the essence of policymaking is the struggle over ideas, rather than over concrete, quantifiable, or non-subjective things. Many scientific discussions dismiss these factors as hindrances to good management, rather than acknowledging their centrality to the process.

How a policy issue is framed and how problems are defined is critical because they tend to color the way we think, talk about, and approach a policy issue. This can implicitly favor some values, players, and solutions over others. Multiple competing definitions of the wolf problem (i.e., wolves and the need for wilderness; wolves and the need for ecological restoration; wolves as federal Trojan horse; wolves and urban subjugation of rural values; etc.) have serious implications for any management approach.

Nie examines the political-cultural and sociological context of wolf management in the U.S. He argues that wolf politics and policy are about much more than wolves and their management. Carnivore conservation is often surrogate for broader cultural conflicts: preservation versus use of resources; recreation-based economies versus extraction-dependent economies; urban versus rural values; states' rights versus federalism; etc.

Deciding how decisions should be made—from the proper balance of scientists and stakeholders to who should be invited to the decision-making table—is often central. Overall, Nie argues that successful efforts will depend on how well professionals understand and attend to this sociopolitical context, as well as the questions and challenges that it raises.

Nie MA. 2002. Wolf Recovery and Management as Value-Based Political Conflict. *Ethics, Place and Environment* 5(1):65-71.

Conflict over wolf management might be best understood as value-based political conflict, occurring over a deeply symbolic animal in a very controversial political and cultural context—one that transcends issues strictly pertaining to science, biology, and technical problem-solving. However, it is not just a question of what values are involved in the wolf debate, but where these values are located and what power they wield in the decision-making process. For instance, some groups argue that there is a serious divide between the institutional values of state fish and game departments and those of the public at large.

Competing ideas of the public interest are at the heart of wolf policy. The proper role of science is a recurring theme. Science can help answer a question such as how much livestock predation can be expected from a wolf population in a national forest area, but it cannot answer normative questions such as whether wolves or cows should be in that national forest area. This is a distinction that is often ignored in management debates.

Nie argues that political and cultural context will continue to shape the future of the wolf, and, as such, place matters. The political and cultural landscapes in which wolves are making their return are as varied as their physical environments. In the Northern Rockies, for instance, the situation is characterized by public land and public land agencies; it is a story of bureaucratic politics, environmentalists, and ranchers.

Nie suggests that those engaged in the debate should acknowledge its value-based character. It is important for the wolf decision-making process to be as inclusive, participatory, and representative as possible. The process must offer more access and accountability. Multiple stakeholders with multiple values must be given a larger role. Ultimately, Nie argues, a well-structured stakeholder framework can offer a more constructive way of dealing with value-based political conflict and the sociopolitical dimensions of wolf-recovery.

Nie MA. 2004. State Wildlife Policy and Management: The Scope and Bias of Political Conflict. *Public Administration Review* 64(2):221-33.

State wildlife management is often characterized by divisive political conflict. Policy and management decisions are often made by state wildlife commissions, boards, or councils, and are perceived by some as biased, exclusive, or unrepresentative of non-consumptive stakeholder values, which has led to many groups now using ballot initiatives to influence wildlife policy and management decisions.

There are important ramifications associated with management by ballot initiative—ramifications of concern to many wildlife professionals. Adversarial and dichotomous (yes/no, for/against) policy making inhibits deliberation, meaningful dialogue, and compromise. Quality and stability of public opinion concerning wildlife-related issues is up for debate. Science, biology, and professional wildlife management may or may not be able to play a real role in the process. Special interest groups and money wield great power under such a scheme. Tyranny of the majority situations are also possible (less numerous rural citizens are often disproportionately affected by wildlife decisions).

Nie discusses the history of state wildlife management agencies, as well as the management structures and paradigms that have historically characterized them, and explores several alternative options for state wildlife policy-making and management.

New voices are likely to play a more important role in wildlife policy making and management. It is worth asking whether this expanding scope will simply lead to increased gridlock. Ballot initiative and collaborative conservation both have their strengths and weaknesses, but they have at least one thing in common—both expand the scope and bias of wildlife-centered political conflict. Nie argues that all prospective methods for developing policy deserve careful examination, particularly how they might enhance effectiveness, accountability, and/or promote democratic values that safeguard the public interest in wildlife.

Nie M, Barns C, Haber J, Joly J, Pitt K, Zellmer S. 2017. Fish and Wildlife Management on Federal Lands: Debunking State Supremacy. *Environmental Law* 47(4):1-126.

Nie et al. review the authority of federal and state governments to manage wildlife on federal lands and describe the most common assertions made by state governments regarding state powers over wildlife. They then analyze the relevant powers and limitations of the U.S. Constitution and federal land laws, regulations, and policies.

The authors make the case that federal land management agencies have an *obligation*, not just the *discretion*, to manage and conserve fish and wildlife on federal lands. They argue that the "myth" that "the states manage wildlife and federal land agencies only manage wildlife habitat" is not only wrong

from a legal standpoint but it leads to fragmented approaches to wildlife conservation, unproductive battles over agency turf, and an abdication of federal responsibility over wildlife.

Further, the authors highlight ample opportunities in federal land laws for constructive intergovernmental cooperation in wildlife management. Yet, they argue, many of these processes are not used to their full potential, and states sometimes use them as a means of challenging federal authority rather than a means of solving common problems. The authors conclude that intergovernmental cooperation must be a mutual and reciprocal process, meaning that state agencies need to constructively participate in existing federal processes, and federal agencies need to be provided meaningful opportunities to participate in, and influence, state decision-making affecting federal lands and wildlife.

Northrup J, Stenhouse G, Boyce M. 2012. Agricultural Lands as Ecological Traps for Grizzly Bears. *Animal Conservation* 15:369–77. DOI:10.1111/j.1469-1795.2012.00525.x

Human-carnivore conflicts on agricultural lands are a global conservation issue affecting carnivore population viability, as well as human safety and livelihoods. Locations of conflicts are influenced by both human presence and carnivore habitat selection, although these two aspects of conflict rarely have been examined concurrently. Understanding patterns of conflict (where and why they occur) and finding ways to reduce conflict are important in large carnivore conservation.

Northrup et al. reviewed 10 years of data on conflicts between grizzly bears and humans in southwestern Alberta, Canada, using logistic regression models in a geographic information system to map the probability of bear-human conflict from these data, and the relative probability of grizzly bear habitat selection based on global positioning system radio-telemetry data. They overlaid these maps to identify ecological traps, as well as areas of secure habitat.

Northrup et al. found that patterns of bear-human conflict in the study area resulted from overlap between human developments and highly selected habitats. These areas of overlap were almost exclusively on private lands, and the probability of bear-human conflict was higher in areas adjacent to quarter sections in which there had been a conflict, indicating a non-random distribution of risk areas. The majority of the habitats highly selected by grizzly bears directly coincided with areas of high conflict risk. Private agricultural lands contained almost the entirety of habitats selected by bears, and more than 50% of these lands were classified as ecological traps at night when the bears were most active. Northrup et al. found that bears in the area have little secure habitat.

The authors conclude that small steps, such as reducing bear attractants is necessary, yet this is not enough when conflicts ultimately are a result of humans living and working in prime bear habitats. They suggest, to ensure self-sustaining populations of large carnivores in southwestern Alberta, humans must be willing to coexist, which will require management agencies and conservation groups to work directly with agricultural stakeholders.

Nyhus PJ. 2016. Human-Wildlife Conflict and Coexistence. *Annual Review of Environment and Resources* 41:143-71. DOI:10.1146/annurev-environ-110615-085634.

Human interactions with wildlife—positive or negative—are a defining experience of human existence. People compete with wildlife for food and resources, and have eradicated dangerous species; co-opted and domesticated valuable species; and applied a wide range of social, behavioral, and technical approaches to reduce negative interactions with wildlife. This conflict has led to the extinction and reduction of numerous species and uncountable human deaths and economic losses.

Recent advances in our understanding of conflict have led to a growing number of positive conservation and coexistence outcomes. Nyhus summarizes and synthesizes factors that contribute to conflict, approaches that mitigate conflict and encourage coexistence, and emerging trends and debates. Fertile areas for scholarship include scale and complexity; models and scenarios; understanding generalizable patterns; expanding boundaries of what is considered conflict; using new tools and technologies; information sharing and collaboration; and the implications of global change.

Nyhus suggests that the time may be ripe to identify a new field—anthrotherology—that brings together scholars and practitioners from different disciplinary perspectives to address human–wildlife conflict and coexistence.

Obbard ME, Howe EJ, Wall LL, Allison B, Black R, Davis P, Dix-Gibson L, Gatt M, Hall MN. 2014. Relationships Among Food Availability, Harvest, and Human-Bear Conflict at Landscape Scales in Ontario, Canada. *Ursus* 25(2):98-110. DOI:10.2192/URSUS-D-13-00018.1

Managers of American black bears must maintain populations to ensure both viability and opportunities for sport harvest, as well as minimize human-bear conflict (HBC). In order to achieve this goal, wildlife managers frequently infer trends in bear populations from changes in harvest metrics, and typically evaluate the efficacy of programming to prevent HBC from trends in the number of conflicts reported by the public. However, evidence that larger harvests reduce HBC is lacking, and changes in harvest metrics and the frequency of HBC may be independent of bear density.

Understanding relationships among food availability, hunter effort, harvest, and HBC could help managers avoid making invalid inferences about population status from data describing harvest and HBC, and evaluate whether management actions are having intended results. Obbard et al. investigated relationships among food availability, HBC, and harvest at landscape scales in Ontario, Canada, from 2004 through 2011.

Using a Spearman rank correlation to test for trends in the data, the authors found that both HBC and total harvest were negatively correlated with food availability across Ontario. Given the variation of natural foods, the authors predict that harvest is unlikely to prevent elevated levels of HBC in years of food shortage unless it maintains bears at low densities—an objective that may conflict with maintaining viable populations and ensuring opportunities for sport harvest. They suggest that the availability of natural foods is a factor that influences harvest metrics and measures of HBC, and without considering the relationships among food availability, HBC, and harvest, wildlife managers may come to incorrect conclusions regarding bear populations and the effectiveness of their management actions.

Olson ER, Stenglein JL, Shelley V, Rissman AR, Browne-Nunez C, Voyles Z, Wydeven AP, Van Deelen T. 2014. Pendulum Swings in Wolf Management Led to Conflict, Illegal Kills, and a Legislated Wolf Hunt. *Conservation Letters* 8(5): 1-10. DOI:10.1111/conl.12141

Conflict over wildlife can occur when wildlife management actions are incompatible with the values of some stakeholders (Zinn et al. 1998; Shelley et al. 2011). Sociopolitical forces can reinforce conflict and trigger intractable debates, such as conflict over gray wolf management (Messmer et al. 2001; Nie 2002, 2003; Gray 2004). Interests of empowered stakeholders can determine wildlife policy (Rinfret 2011), leading to management that may be inconsistent with broader public support.

Sociopolitical conflict over wildlife can be visualized as a pendulum swinging between exploitative and protective management as different stakeholder groups gain political power, producing inconsistency in wildlife management (Messmer et al. 2001). Yet, while debates occur in public meetings, board rooms, and within the legal system, the effects of sociopolitical conflict unfold on the ground between people and wildlife (Nie 2003).

Through an interdisciplinary approach, Olson et al. explored the complex dynamics of wolf management options, public attitudes, and illegal killing of wolves in Wisconsin during a period of intense sociopolitical conflict (2003–2011). They found that swings in wolf status led to inconsistent management authority, declining local public support for wolves, and possibly the unintended backlash of more illegal kills and a legislatively mandated public wolf hunt.

The authors argue that moderating the sociopolitical drives of swings in policy over short periods is essential to allow wildlife managers greater flexibility in achieving species-specific goals. They recommend that states avoid prescriptive harvest legislation and suggest a more incremental shift from federal to state management authority.

Olson ER, Van Deelen TR, Wydeven AP, Ruid DB, MacFarland DM, Ventura SJ. 2019. A Landscape of Overlapping Risks for Wolf-Human Conflict in Wisconsin, USA. *Journal of Environmental Management* 248:109307. DOI:10.1016/j.jenvman.2019.109307

Risk maps can be valuable tools for natural resource managers, allowing them to better understand spatial characteristics of risk. Risk maps can also support risk-avoidance efforts by identifying which areas are relatively riskier than others. However, risks, such as human-carnivore conflict, can be diverse, multi-faceted, and overlapping in space. Yet, efforts to describe risk typically focus on only one aspect of risk.

Olson et al. examined wolf complaints investigated in Wisconsin for the period of 1999–2011. They described the spatial patterns of four types of wolf-human conflict: livestock depredation, depredation on hunting hounds, depredation on non-hound dogs, and human health and safety concerns (HHSC). Using predictive landscape models and discriminant functions analysis, they visualized the landscape of risk as a continuous surface of overlapping risks. Each type of conflict had its own unique landscape signature; however, the probability of any type of conflict increased closer to the center of wolf pack territories and with increased forest cover. Hunting hound depredations tended to occur in areas considered to be highly suitable wolf habitat, while livestock depredations occurred more regularly in

marginal wolf habitat. HHSC and non-hound dog depredations were less predictable spatially but tended to occur in areas with low housing density adjacent to large wildland areas.

Similar to other research evaluating the risk of human-carnivore conflict, the authors found that human-carnivore conflict is most likely to occur where humans or human property and large carnivores co-occur. However, identifying areas of co-occurrence is only marginally valuable from a conservation standpoint and could be described using spatially-explicit human and carnivore data without complex analytical approaches. They suggest that a more comprehensive understanding of the risk of human-carnivore conflict can be achieved by examining the spatial and non-spatial factors influencing risk *within* areas of co-occurrence and by describing the landscape of risk as a continuous surface of multiple overlapping risks.

Ordiz A, Bischof R, Swenson JE. 2013. Saving Large Carnivores, but Losing the Apex Predator? *Biological Conservation* 168:128-33. DOI:10.1016/j.biocon.2013.09.024

The widespread decline in numbers and distribution of large carnivores due to human persecution has led to a loss and reconfiguration of biological diversity in many ecosystems, highlighting the ecological effect of the carnivores and the broad-scale consequences of their loss (Terborgh et al. 2001, Ray et al. 2005, Terborgh and Estes 2010, Estes et al. 2011).

Carnivores are frequently used as flagship species whose conservation benefits can extend to entire communities (Sergio et al. 2008). Nevertheless, conservation of large carnivores remains controversial, forcing managers to make compromises. Hunting of large carnivores occurs worldwide and is sometimes used as a management tool to support carnivore conservation (Treves and Karanth 2003, Linnell et al. 2007, Treves 2009). However, killing carnivores can disrupt their social organization, affecting both carnivore population dynamics and management goals.

Ordiz et al. found that while hunting may directly or indirectly separate carnivores from humans and their property, which is important for conflict avoidance (Treves and Karanth 2003), the complex behavioral ecology of large carnivores, their ecosystem-wide effects, and the ramifications of human exploitation lead them to question whether carnivores subjected to exploitation and pre-emptive control can effectively fulfill their ecological role. They suggest five recommendations for large carnivore managers to consider.

Parker ID, Feldpausch-Parker AM. 2013. Yellowstone Grizzly Delisting Rhetoric: An Analysis of the Online Debate. *Wildlife Society Bulletin* 37(2): 248-55. DOI: 10.1002/wsb.251.

The Yellowstone grizzly bear delisting debate illustrates how rhetoric can contribute to fragmentation and polarization among stakeholders engaged in endangered species conflicts. The partisan view of the grizzly ideograph, and what it represented, created impediments to conflict management (e.g. mistrust and development of and/or belief in stereotypes. The debate coalesced as the U.S. Fish and Wildlife Service began proceedings to delist the Yellowstone population from the endangered list in 2005.

Parker and Feldspausch-Parker used a rhetorical analysis of the internet-based debate to identify strategies used by disputants in conflicts over the Endangered Species Act. By analyzing web-based

stakeholder texts from 1998 through 2009, they found that rhetoric about grizzly bears fell into three main categories of rhetoric appeal: authority, ethics, and identity.

Parker and Feldspausch-Parker found that arguments relying on these appeals contributed to destructive communication about stakeholders. They also found that perspectives toward climate change influenced perception of grizzly delisting. They demonstrated how rhetorical analyses can reveal disputants' preferred social control frameworks, which they suggest can be important information for managers seeking to promote common ground between otherwise conflicted stakeholders.

Peck C, van Manen F, Costello C, Haroldson M, Landenburger L, Roberts L, Bjornlie D, Mace R. 2017. Potential Paths for Male-Mediated Geneflow to and from an Isolated Grizzly Bear Population. *Ecosphere* 8(10):1-19. DOI:10.1002/ecs2.1969

Conserving movement corridors for mammalian carnivores is challenging because they frequently span large geographic areas comprised of complex landscape mosaics with varied land ownerships and uses. While grizzly bears of the Northern Continental Divide Ecosystem (NCDE) experience genetic flow and connectivity with populations in the Canadian Rockies, current genetic data indicate that the Greater Yellowstone Ecosystem (GYE) population remains isolated. Genetic connectivity between these populations remains a long-term management goal among state and federal agencies and numerous conservation non-profits.

Developing conductance layers integrating ecological, physical, and anthropogenic landscape features with GPS locations from 124 grizzly bears, Peck et al. modeled predictions of male grizzly movement between the GYE and NCDE. They identified several interconnected areas with concentrated paths along neighboring mountain ranges that may serve as stepping stones to male grizzly bear dispersal between the two ecosystems. Concentrated paths followed the Big Belt and Bridger Mountains in addition to the Tobacco Root Mountains of Southwestern Montana.

This spatially explicit information is purposed to aid land managers and organization working with private land owners to identify and prioritize conservation measures to maintain of enhance the integrity of areas supporting potential dispersal of male grizzly bears between the GYE and NCDE ecosystems.

Peebles KA, Wielgus RB, Maletzke BT, Swanson ME. 2013. Effects of Remedial Sport Hunting on Cougar Complaints and Livestock Depredation. *PLoS ONE* 8(11):e79713. DOI:10.1371/journal.pone.0079713.

Sport hunting is often used as a preventative or remedial measure to reduce carnivores and related human complaints and/or livestock depredations for many predators. However, the assumption that increased sport hunting reduces complaints and depredations did not appear to have been scientifically tested.

Using cougars as their study animal, Peebles et al. collected data on numbers of complaints, livestock depredations, cougars harvested, estimated cougar populations, and human and livestock populations for all 39 counties and 136 game management units in the state of Washington from 2005 through 2010.

As expected, they found that complaints and depredations were positively associated with human, livestock, and cougar populations. However, Peebles et al. found that remedial sport hunting to reduce complaints and depredations actually appeared to be associated with increased, not decreased, complaints and depredations the following year.

Primm SA, Wilson SM. 2004. Reconnecting Grizzly Bear Populations: Prospects for Participatory Projects. *Ursus* 15(1):104-14.

Grizzly bear populations will generally benefit from linkage habitat that connects them with other subpopulations. Much discussion of linkage habitat focuses on ecological information, but Primm and Wilson argue that we should not overlook the cultural and political dimensions of these landscapes.

People living with recovering and expanding populations have valuable insight and practical knowledge that should inform management and conservation programs. This requires a systematic approach to understanding social context and involving people in research and planning. It will provide good prospects for designing innovative programs adapted to local situations. The authors argue that small-scale participatory projects can be models for subsequent conservation projects, as well as building political support by demonstrating success.

Primm and Wilson outline several foundational elements for conserving linkage habitat: sequential projects beginning in occupied habitat, project areas scaled/matched to human communities, effective and extensive social context mapping, and integration of projects with existing efforts. They authors also outline a framework for effective and equitable participatory conservation, and point out that participatory problem solving should not be all talk; these processes can and should focus on tangible outcomes. Burnout is high among volunteers and stakeholders if they feel no sense of progress or accomplishment.

Dialogue separate from authoritative decision-making is a key element, because it addresses the value conflicts that underlie disputes over conservation. The authors reiterate that action and dialogue should be interwoven. It is also important for practitioners to have clear objectives and communicate with one another to coordinate and share lessons. Finally, they suggest that small-scale projects can serve as models for leveraging larger conservation efforts.

Proctor M, Kasworm W, Annis K, MacHutchon A, Teisberg J, Radandt T, Servheen C. 2018. Conservation of Threatened Canada-USA Trans-border Grizzly Bears Linked to Comprehensive Conflict Reduction. *Human–Wildlife Interactions* 12(3):348-72. DOI:10.26077/yjy6-0m57

Long-term wildlife conflicts can impact the conservation of wildlife species, resulting in population decline, range contraction, and loss of inter-population connectivity. Human conflict has resulted in fragmented, small, and threatened grizzly bear populations in the Canada-USA trans-border region of Western North America. Three populations, comprised of the South Selkirk (>83 grizzly bears), the Cabinets (24 grizzly bears), and the Yaaks (48 grizzly bears) experience varying levels of genetic isolation due to fragmentation and human-caused mortalities.

Proctor et al. implemented a comprehensive program to reduce human-wildlife conflict within the South Selkirk, Cabinet, and Yaak populations and then measured the effect of this program on two indices of conservation status—human-caused mortality and inter-population connectivity. The program to reduce conflicts primarily included strategic private lands purchased to reduce human density in wildlife corridors, the reduction of bear attractants where human settlement and agriculture exists, and the nonlethal management of conflict bears.

A significant decrease in human-caused mortality of bears, an increase in inter-population movement and gene flow, and increased backcountry habitat effectiveness show compelling evidence of the merits of the authors' multi-faceted conflict reduction programs. The authors consider this study to be a blueprint for recovering small, fragmented grizzly bear populations in British Columbia, Alberta, and Western North America.

Proctor MF, Nielsen SE, Kasworm WF, Servheen C, Radandt TG, Machutchon AG, Boyce MS. 2015. Grizzly Bear Connectivity Mapping in the Canada-United States Trans-Border Region. *Journal of Wildlife Management* 79(4):544-88. DOI:10.1002/jwmg.862

Fragmentation of large carnivore populations at the southern extent of their North American distributions has led to increased attention on issues of connectivity. Specifically, there is growing interest in identifying numerous methods for identifying wildlife corridors or linkage areas to reverse fragmentation of habitat and population.

Human-caused mortality associated with settlement along highways is a primary mechanism of population fragmentation in the Canada-United States trans-border region (Proctor et al. 2012).

For grizzly bears in particular, extensive population fragmentation exists throughout the Canada-US trans-border region of southern British Columbia and Alberta, and northern Montana, Idaho, and Washington. Small, subpopulations with minimal or no female interchange are separated by human presence and highways. Long-term survival depends on reconnecting them with larger regional subpopulations.

Proctor et al. (2012, 2016) recommend management actions to increase linkage areas between regional subpopulations to enhance survival and demographic exchange, using a predictive method for identifying linkage areas (resource selection function models based on grizzly GPS) in regions where bears are crossing highways as well as in regions where they are not. While crossing structures can be important tools to reduce highway mortalities and enhance wildlife connectivity, Proctor et al. (2012) found human settlements to be the most important fracturing force for grizzly bears regionally. This pattern suggests that management strategies that reduce grizzly bear mortality from human conflict and minimize human densities in linkage areas may help increase successful inter-area movements.

Ramler JP, Hebblewhite M, Kellenberg K, Sime C. 2014. Crying Wolf? A Spatial Analysis of Wolf Location and Depredations on Calf Weight. *American Journal of Agricultural Economics* 96(3):631-56. DOI:10.1093/ajae/aat100

Historically, studies examining the impact of predators such as wolves on domestic livestock have been conducted using direct depredation rates (e.g., Sommers et al. 2010, Muhly and Musiani 2009, Bradley

and Pletscher 2005). However it has been suggested that predators may have impacts on livestock that reach beyond direct depredation (Kluever et al. 2008, Howery and DeLiberto 2004).

One claim in particular is that wolves decrease the average weight of calves (Alderman 2006, Steele et al. 2013) by stressing mother cattle, increasing movement rates, or encouraging inefficient foraging behavior. Using data from Montana ranches and spatial data on known wolf pack locations and climatological data from 1995 to 2010, Ramler et al estimated the spatial impact of changing wolf pack locations and confirmed wolf depredations on the weight of beef calves.

The authors found no evidence that wolf packs with home ranges that overlapped ranches had any detrimental effects on calf weights. Other non-wolf factors, notably climate and individual ranch-specific husbandry practices, explained the majority of the variation in weight. However, ranches that experience a confirmed cattle depredation had a negative and statistically significant impact on the average calf weight across their herd.

For ranches experiencing confirmed depredation, these indirect costs are shown to be potentially greater than direct depredation costs. Ramler et al. suggest these results demonstrate a potentially important and understudied aspect of economic conflict arising from the protection and funding of the endangered species recovery programs.

Ravenelle J, Nyhus PJ. 2017. Global Patterns and Trends in Human-Wildlife Conflict Compensation. *Conservation Biology* 31(6):1247-56. DOI:10.1111/cobi.12948

Human–wildlife conflict is a major conservation challenge, and compensation for wildlife damage is a widely used economic tool to mitigate this conflict; however, the effectiveness of this management tool is widely debated. The relative importance of factors associated with compensation success is unclear, and little is known about global geographic or taxonomic differences in the application of compensation programs.

Ravenelle and Nyhus reviewed research on wildlife-damage compensation to determine geographic and taxonomic gaps, analyze patterns of positive and negative comments related to compensation, and assess the relative magnitude of global compensation payments. They analyzed 288 publications referencing wildlife compensation and identified 138 unique compensation programs. These publications reported US$222 million (adjusted for inflation) spent on compensation in 50 countries since 1980. Europeans published the most articles, and compensation funding was highest in Europe, where depredation by wolves and bears was the most frequently compensated damage. Authors of the publications reviewed made twice as many negative comments as positive comments about compensation. Three-quarters of the negative comments related to program administration. Conversely, three-quarters of the positive comments related to program outcomes. The three most common suggestions to improve compensation programs included requiring claimants to employ damage prevention practices, such as improving livestock husbandry or fencing of crops to receive compensation; modifying ex post compensation schemes to some form of outcome-based performance payment; and altering programs to make compensation payments more quickly.

The authors suggest that further understanding of the strengths and weaknesses of compensation as a conflict-mitigation tool will require more systematic evaluation of the factors driving these opinions and

that differentiating process and outcomes and understanding linkages between them will result in more fruitful analyses and ultimately more effective conflict mitigation.

Redpath SM, Linnell JDC, Festa-Bianchet M, Boitani L, Bunnefeld N, Dickman A, Gutierrez RJ, Irvine JR, Johansson M, Majic A, McMahon BJ, Pooley S, Sandstrom C, Sjolander-Lindqvist A, Skogen K, Swenson JE, Trouwborst A, Young J, Milner-Gulland EJ. 2017. Don't Forget to Look Down—Collaborative Approaches to Predator Conservation. *Biological Reviews* 92:2157-63. DOI:10.1111/brv.12326

Finding effective ways of conserving large carnivores is widely recognized as a priority in conservation. However, there is disagreement about the most effective way to do this, with some favoring top-down "command and control" approaches and others favoring collaboration. Counterbalancing the arguments of Treves et al. (2017), Redpath et al. considered the potential merits of collaborative approaches, questioning the sole focus on "coercive" approaches.

The authors reported that in many parts of the developed world, flexibility of approach is built into the legislation, so that conservation objectives are balanced with other legitimate goals. In the developing world, limited resources, poverty and weak governance mean that collaborative approaches are likely to play a particularly important part in carnivore conservation. They argued that in general, coercive policies may lead to the deterioration of political legitimacy and potentially to non-compliance issues such as illegal killing, whereas collaborative approaches may lead to psychological ownership, enhanced trust, learning, and better social outcomes. They conclude that there are many different models for how to conserve carnivores effectively across the world; research is now required to reduce uncertainty and examine the effectiveness of these approaches in different contexts.

Reyna-Saenz F, Zarco-Gonzalez MM, Monroy-Vilchis O, Antonio-Nemiga X. 2019. Regionalization of Environmental and Anthropic Variables Associated to Livestock Predation by Large Carnivores in Mexico. *Animal Conservation.* DOI:10.1111/acv.12527

Conflicts with humans are one of the main causes of the decline in populations of large carnivores, making it a crucial conservation issue worldwide. In Mexico, jaguar, puma, and American black bear are involved in livestock predation and are persecuted in retaliation. The sites where predation occurs are distributed throughout the country and differ not only in environmental characteristics, but also in social, economic, and livestock management practices. However, due to the general focus of the studies conducted to date, proposed mitigation measures are also general.

Reyna-Saenz et al. identified the environmental and anthropic conditions in which livestock predation occurs by jaguar, puma, and American black bear in Mexico, as well as clusters of similar cases, in order to propose priority actions for the mitigation of predation in each cluster. The variables most related to predation sites were identified, with a high percentage of them being livestock management practices, and clusters of similar sites were analyzed for their spatial distribution, which presented grouping patterns in the cases of predation by puma and black bear, in contrast to the jaguar clusters, which presented a dispersed distribution.

The authors propose as mitigation measures the confinement of livestock, construction or improvement of corrals, and improvement of management practices. The anthropic component and livestock management practices are closely related to the predation events and, therefore, their inclusion in the conservation programs of carnivores in Mexico is fundamental.

Rich LN, Mitchell M S, Gude JA, Sime CA. 2012. Anthropogenic Mortality, Intraspecific Competition, and Prey Availability Influence Territory Sizes of Wolves in Montana. *Journal of Mammalogy* 93(3):722. DOI:10.1644/11-MAMM-A-079.2.

Rich et al. examined factors determining wolf pack territory sizes in Montana and determined that terrain ruggedness, human densities, prey availability, and number of surrounding wolf packs were all factors predicting territory sizes. The authors also found a strong positive relationship between lethal controls and territory size, with the mechanism behind this relationship remaining unclear. The authors did not test the changing social dynamics within packs through the removal of breeders or experienced pack members and concluded that further exploration of the relationship between lethal controls and territory size is needed.

Richie L, Oppenheimer JD, Clark SG. 2012. Social Process in Grizzly Bear Management: Lessons for Collaborative Governance and Natural Resource Policy. *Policy Sciences* 45(3):265-91. DOI:10.1007/s11077-012-9160-z.

After years of acrimony and deprivation of values among many participants in the grizzly bear debate, in 2005 Parks Canada initiated a small-scale trial intervention with the goal of learning about a system and improving outcomes (Willard and Norchi 1993, Lasswell and McDougal 1992). This Grizzly Bear Dialogue Group (GBDG) convened a small number of diverse stakeholders to meet regularly to discuss grizzly bear issues and generate management recommendations whose overriding goal was to advance human dignity (Clark 2011).

Richie et al. mapped and appraised the GBDG's social process and examined lessons learned from the process that was uniquely grounded in and directly applying the policy sciences while representing years of stakeholder collaboration. The authors found that the GBDG was a direct and practical application of the policy sciences' problem solving approach to real-life and high-profile natural resource problems. They suggest that an effective social process is critical to fostering participants' collective ability to find common ground.

Robins CW, Kertson BN, Faulkner J, Wirsing AJ. 2019. Effects of Urbanization on Cougar Foraging Ecology Along the Wildland-Urban Gradient of Western Washington. *Ecosphere* 10(3):e02605. DOI:10.1002/ecs2.2605

Humans have dramatically altered ecosystem structure through landscape manipulation, often leaving refuge patches of suitable habitat for wildlife amid inhospitable terrain. Large carnivores are especially vulnerable to such habitat modification because they tend to have low population densities and wide-ranging movements necessitated by their food requirements. Cougars, unlike many other large carnivores, have demonstrated an ability to exploit resources in fragmented and managed landscapes. The influence of increasing landscape development on cougar foraging behavior, however, has yet to be fully explained.

Robins et al. investigated variation in cougar use of three prey types (synanthropes, ungulates, and rodents) along a wildland–urban gradient in western Washington to determine how urbanization affects the foraging ecology of this apex predator. They predicted that cougar diets would comprise more synanthropic prey (e.g., prolific urban species) and fewer deer as a function of increasing residential

development. Generalized linear mixed model results showed that the odds of cougar predation on synanthropic prey did increase with urbanization. The odds of ungulate predation, however, remained relatively consistent across the wildland–urban gradient despite cougar use of black-tailed deer and elk increasing over time.

The authors found that cougar–ungulate predator–prey systems can persist in landscapes with substantial human presence. Most cougars exhibited similar diets, but certain individuals deviated significantly from the population averages characterizing use of all three major prey categories. This variation suggests that cougar population responses to urbanization are unlikely to be uniform and that cases of human–cougar conflict may be linked to individual cats, rather than the population as a whole.

Robinson HS, Wielgus RB, Cooley HS, Cooley SW. 2008. Sink Populations in Carnivore Management: Cougar Demography and Immigration in a Hunted Population. *Ecological Applications* 18(4):1028-37. DOI:10.1890/07-0352.1

Sport hunting is widely invoked as an effective tool for reducing human-carnivore conflicts while maintaining viable populations. However, the way in which carnivore populations respond to harvests can vary greatly depending on their social structure, reproductive strategies, and dispersal patterns. Although hunting cougars on a broad geographic scale can reduce densities, hunting in smaller areas, such as game management units, could conceivably be counterproductive (in terms of reducing populations or conflicts) because it can fuel increased immigration from adjacent source areas.

Robinson et al. monitored a heavily hunted cougar population to test for the effects of hunting at a small scale, and to gauge whether population control was achieved or whether hunting losses were negated by increased immigration. The authors observed no decline in the density of the total population or the adult population within their study area, but observed a significant decrease in the average age of independent males. They found that the male component of the population increased, masking a decrease in the female component. Overall, the authors' data support a compensatory immigration sink hypothesis—cougar removal in small game management areas increased immigration and recruitment of younger animals from adjacent source areas, resulting in little or no reduction in local cougar densities and a shift in population structure toward younger animals. Hunting in high-quality habitats may create an attractive sink, leading to misinterpretation of population trends and masking overall population declines in the sink and surrounding source areas.

The authors argue that informed management decisions require an accurate assessment of carnivore abundance and population rates. Hunting pressures can often be concentrated in areas that have high habitat quality and therefore highest cougar densities. Robinson et al.'s findings show that these same hunted areas probably act as sinks, maintaining stable populations through increased immigration from surrounding source areas. If population estimates are based on these heavily hunted sink populations, off-take of recent immigrants could produce the illusion of a growing population in the greater region.

Roever C, Boyce M, Stenhouse G. 2010. Grizzly Bear Movements Relative to Roads: Application of Step Selection Functions. *Ecography* 33:1113-22. DOI:10.1111/j.1600-0587.2010.06077.x.

Access management is an important facet of grizzly bear conservation in North America. Understanding how bears move relative to human travel corridors is important in contexts where most grizzly bear

mortalities are human-caused. Roever et al. examined how bears move relative to roads in Alberta, where nearly all grizzly bear mortalities are caused by humans and occur near roads and trails. The authors applied step-selection functions to model habitat selection and movements of grizzly bears.

Roever et al. found that bears of both sexes and all ages were more likely to select steps closer to roads, irrespective of traffic volume. Roads are associated with attractive habitats for bears (such as forestry/logging cut blocks, which are associated with several grizzly bear foods in this area). Models substituting cut blocks for roads outperformed road models in predicting bear selection during day, dawn, and dusk.

Bear step lengths increased near roads and were longest near highly trafficked roads indicating faster movements when near roads. Bear selection of roads was consistent throughout the day. Nevertheless, time of day had a strong influence on selection of forest structure and terrain variables. At night and dawn, bears selected forests of intermediate age, and chose older forests during the day. Solar radiation values were selected-for at dawn. Bears chose steps closer to edges at dusk.

Roever et al. note other studies finding that grizzly bear avoidance of roads was contingent on traffic volume near highways (as well as less-trafficked logging roads). They also point out that inferring causation is challenging in regard to these observations. The authors postulate that roads are an attractant because they are associated with cut blocks (which contain bear foods) and because they are located in appealing lower-elevation valley habitats. But roads are also a source or mortality, so increasing step-length may be due to quicker movement or straighter path to reduce time spent at risk near roads. At night, roads also can provide convenient trails between cut blocks or other food patches, so roads are used for travel, again resulting in longer step lengths.

To decrease bear mortality near roads, the authors argue that managers must either reduce sources of attraction near roads or reduce sources of mortality. Several tools are available to address these challenges. When grizzly bear habitat preferences overlap human activities, the likelihood of human-bear interactions (and attendant conflicts) increases. Mitigating or reducing this overlap will aid in grizzly bear conservation.

Rush T, Haroldson M, Murphy K, Boutte P, Hornocker M, Quigley H. 2011. Cougar Survival and Source-Sink Structure on Greater Yellowstone's Northern Range. *Journal of Wildlife Management* 75(6):1381-98. DOI:10.1002/jwmg.190.

Cougars have a great ability to persist in a variety of habitats, provided there is adequate cover and prey. However, habitat quality may vary spatially and temporally and affect cougar survival and production. Ultimately, survival of individuals and population resiliency may be strongly influenced by various factors including land use (roads, livestock, development), management through hunting and depredation removal, and by competition with other carnivores.

Rush et al. studied survival and causes of mortality of radio-collared cougars in the Greater Yellowstone Northern Range (GYNR) prior to (1987–1994) and after (1998–2005) wolf reintroduction, and evaluated temporal, spatial, and environmental factors that explain variation in adult, sub-adult, and kitten survival.

The authors found that the most significant determinants of survival were age and sex of the cougar, elevation, and density of roads in a cougar's home range during the cougar hunting season. Survival increased as females and males aged but then rapidly declined at older ages, around 8 to 10 years. Generally, female cougars in the study area had higher survival than males.

The possible effect of increased wolf presence on survival was small compared with effects of age, sex, elevation, and density of roads during the hunting season. Wolves caused 15% of adult cougar deaths and all occurred during winter. Although the influence of increasing wolf presence and use is not clear from the survival modeling, cougars responded to increasing wolf use by concentrating their activities in more topographically complex habitats.

Low elevations and increasing density of roads, particularly in areas open to hunting, posed greater mortality risk for cougars than in areas of low road density and higher elevations. The findings support other cougar studies and are consistent with findings for other carnivores, like grizzly bears.

Rutherford MB, Gibeau ML, Clark SG, Chamberlain EC. 2009. Interdisciplinary Problem Solving Workshops for Grizzly Bear Conservation in Banff National Park, Canada. *Policy Sciences* 42:163-87.

Developing and implementing successful conservation strategies requires scientists, managers, and advocates to accurately identify the problems, assess what knowledge is needed, integrate information from a variety of sources to develop a reliable understanding of the causal factors underlying problems, and generate effective solutions that are in the common interest.

Rutherford et al. reported on the outcomes from a series of workshops in Canada designed to explore how cognizant participants were of their own standpoints, and how that influenced their perceptions of problems and solutions, in order to engage constructively with each other.

The workshops highlighted five ways in which the policy sciences framework can help collaborative decision-makers be more effective: (1) by encouraging comprehensive thinking about the context for problems, thereby increasing the probability that all of the important variables and concerns relevant to a proposed solution will be taken into account; (2) by guiding participants sequentially through tasks of problem orientation, the framework can help them move beyond simply arguing about trends and promoting preferred alternatives; (3) by encouraging careful consideration of appropriate goals for social and decision-making processes, in addition to traditional goals for biological conservation; (4) by asking participants to examine their own standpoints and consider how their identity and biases shape their own thinking; and (5) talking about social and decision-process issues allowed participants to find common ground, even if they do not initially agree on specific bear management policies.

The authors suggest that their workshops were successful in improving communication within the local community, developing integrated problem solving skills, building understanding and trust, and beginning the process of improving outcomes for bears and people. They offer their approach as a model for pursuing these outcomes in other settings.

Rutledge LY, Patterson BR, Mills KI, Loveless KM, Murray DL, White BN. 2010. Protection from harvesting restores the natural social structure of eastern wolf packs. *Biological Conservation* 143:332-39. DOI:10.1016/j.biocon.2009.10.017.

Human-caused mortality impacts the social dynamics of wolves, and understanding these effects is relevant to managing populations effectively. Strictly numerical approaches to population management fail to account for key factors relating to natural social structure. Rutledge et al. examined ecological and genetic data in Algonquin Provincial Park and adjacent lands in Ontario, Canada, to show that reduced anthropogenic mortality restored the natural kin-based social structure of wolf groups, without a marked change in overall density.

There is growing evidence that maintaining kin relationships in socially structured populations is evolutionarily important and can have positive effects on fitness. Intense harvest may increase adoption of unrelated individuals into packs. High human-caused mortality, even on the periphery of relatively large protected areas, seems to lead to low kinship within packs. This is an issue in terms of restoring not only viable, but also naturally-functioning populations.

The influence of family-based social structures is not well understood in wolves. Nevertheless, Rutledge et al. generally affirm the importance of maintaining the integrity of natural social groups, particularly when viewed in conjunction with studies describing the effects of breeder loss events.

Santiago-Avila F, Cornman A, Treves A. 2018. Killing Wolves to Prevent Predation on Livestock May Protect One Farm but Harm Neighbors. *PLoS ONE* 13(1):e0189729. DOI:10.1371/journal.pone.0189729

Wolves are difficult to protect in mixed-use landscapes due to periodic threats to individuals' property, safety, and livelihood and varied human perception toward their presence. Governments may respond to threats by killing carnivores in an effort to prevent repeated conflicts, although the functional effectiveness of lethal methods has long been questioned. Researchers have made concerted efforts to quantify the efficacy of lethal control on reducing human-carnivore conflicts in order to better inform carnivore management policies and practices.

Santiago-Avila et al. evaluated two methods of government intervention following independent events of verified wolf predation on domestic animals in the Upper Peninsula of Michigan between 1998 and 2014. The study compared the effect of: (1) selective killing of wolves by trapping near sites of verified depredation: and (2), advice to owners and haphazard use of nonlethal predator control methods on future recurrence of livestock depredation.

The authors determined with weak statistical certainty that lethal interventions by the State of Michigan against wolves in the vicinities of verified livestock losses did not appear to reduce future losses, while detecting a spill-over of depredations from farms receiving lethal intervention onto neighbors. The authors argue that there is strong scientific evidence for the effectiveness of at least two nonlethal methods (fladry and livestock guard dogs), while no peer-reviewed study has determined lethal methods to be effective in Michigan. The authors conclude by suggesting the suspension of government-funded trapping in Michigan in favor of nonlethal methods that have been proven effective.

Sawaya MA, Clevenger AP, Kalinowski ST. 2013. Demographic Connectivity for Ursid Populations at Wildlife Crossing Structures in Banff National Park. *Conservation Biology* 27(4):721-30. DOI:10.1111/cobi.12075

Wildlife crossing structures are one solution to mitigating the fragmentation of wildlife populations caused by roads, but their effectiveness in providing connectivity has only been superficially evaluated. Hundreds of grizzly and black bear passages through under and overpasses have been recorded in Banff National Park, Alberta, Canada. However, the ability of crossing structures to allow individual and population-level movements across road networks remains unknown.

Sawaya et al. initiated a 3-year investigation into whether crossing structures provide demographic connectivity for grizzly and black bears in Banff National Park. They collected hair with multiple noninvasive methods to obtain genetic samples from grizzly and black bears around the Bow Valley, in order to determine the number of male and female grizzly and black bears that use crossing structures; examine spatial and temporal patterns of crossings; and estimate the proportions of grizzly and black bear populations in the Bow Valley that use crossing structures.

The number of individuals detected at wildlife crossing structures was highly correlated with the number of passages in space and time. Grizzly bears used open crossing structures (e.g., overpasses) more often than constricted crossings (e.g., culverts). Peak use of crossing structures for both bear species occurred in July, when high rates of foraging activity coincide with mating season. The authors compared the number of bears that used crossings with estimates of population abundance from a related study and determined that substantial percentages of grizzly and black bear populations used crossing structures. Sawaya et al. concluded wildlife crossing structures provide demographic connectivity for bear populations in Banff National Park.

Sazatornil V, Rodgriquez A, Klaczek M, Ahmadi M, Alvares F, Arthur S, Blanco JC, Borg BL, Cluff D, Cortes Y, Garcia EJ, Geffen E, Habib B, Iliopoulos Y, Kaboli M, Krofel M, Llaneza L, Marucco F, Oakleaf JK, Person DK, Potocnik H, Razen N, Rio-Maior H, Sand H, Unger D, Wabakken P, Lopez-Bao JV. 2016. The Role of Human-Related Risk in Breeding Site Selection by Wolves. *Biological Conservation* 201:103-10. DOI:10.1016/j.biocon.2016.06.022

Wolves are the most widely distributed large carnivore species with which humans share the landscape (Mech and Boitani 2003). However, coexistence is largely variable in terms of interaction attributes and conflict intensity (e.g., Agarwala and Kumar 2009, López-Bao et al. 2013, Chapron et al. 2014). Wolves are resilient and able to thrive under a wide spectrum of biotic and abiotic conditions (Mech and Boitani 2003). As a consequence, they have traditionally been considered habitat generalists, with habitat tolerance mainly shaped by food availability and mortality risk (Mech and Boitani, 2003). Such constraining factors of habitat tolerance are the same for most large carnivore species (Woodroffe and Ginsberg 1998, Fuller and Sievert, 2001). Therefore, wolves are a good model species for gaining a better understanding of the behavioral adaptations of large carnivores to humans.

Using data from 26 study areas across wolves' worldwide range, Sazatornil et al. assessed the role of humans in breeding site selection by a large carnivore. Some of the patterns previously observed at the local scale become extrapolatable to the entire species range provided that important sources of variation were taken into account. Generally, wolves minimized the risk of exposure at breeding sites by avoiding human-made structures, selecting shelter from vegetation and avoiding agricultural lands.

The authors' results suggest a scaled hierarchical habitat selection process across selection orders by which wolves compensate higher exposure risk to humans within their territories via a stronger selection at breeding sites. Dissimilar patterns between continents suggest that adaptations to cope with human-associated risks are modulated by the history of coexistence and persecution. Although many large carnivores persisting in human-dominated landscapes do not require large-scale habitat preservation, habitat selection at levels below occupancy and territory should be regarded in management and conservation strategies aiming to preserve these species in such contexts. In this case, the authors recommend providing shelter from human interference at least in small portions of land in order to fulfill the requirements of the species to locate their breeding sites.

Scasta J.D., Stam B, Windh J.L. 2017. Rancher-Reported Efficacy of Lethal and Non-Lethal Livestock Predation Mitigation Strategies for a Suite of Carnivores. *Scientific Reports* 7:14105. DOI:10.1038/s41598-017-14462-1

Pastoralists have dealt with livestock losses from predators for millennia, yet effective mitigation strategies that balance wildlife conservation and sustainable agriculture are still needed today. Globally, the threat predators pose to economic and food security have contributed to the persistence of conflict between humans and carnivores. Subsequently, humans have used a variety of strategies to reduce or eliminate predation including guard dogs and shooting. While recent meta-analyses suggest a general lack of scientific evidence of mitigation strategies reducing the risk of large carnivore predation (Treves 2016), few researchers have engaged ranchers on their perceptions of the effectiveness of varying mitigation strategies.

Scasta et al. surveyed 274 Wyoming ranchers who responded to a retrospective survey and rated the efficacy of predation mitigation strategies for foxes, dogs, coyotes, wolves, bobcats, mountain lions, bears, and birds (buzzards, eagles, hawks, ravens). Ranchers perceive they were most effective at mitigating predation by foxes and coyotes; moderately effective at mitigating large carnivores; and the least effective at mitigating birds. Further, ranchers reported that lethal mitigation strategies were more effective than nonlethal mitigation strategies. However, the authors contend, it is important to note that this is an assessment of one stakeholder group within the predator-livestock community and should be interpreted as such.

The authors suggest that ranchers have difficulty shifting from the predator control paradigm to the coexistence paradigm when the suite of nonlethal methods lack the same level of perceived efficacy. They argue that this perception will continue to hinder predator restoration for carnivores to serve their ecological role relative to trophic cascades.

Scasta J.D., Windh J, Stam B. 2018. Modeling Large Carnivore and Ranch Attribute Effects on Livestock Predation and Nonlethal Losses. *Rangeland Ecology and Management* 71(6):815-26. DOI:10.1016/j.rama.2018.04.009

Ranches that rely on functioning rangeland ecosystems provide extensive spatial habitat for predators; yet, that provision is counteracted by the predator's need for ungulate prey, which can include livestock. The states encompassing the Greater Yellowstone Ecosystem are primarily composed of rangeland that is used for grazing of domestic livestock yet double as important wildlife habitat. Wyoming is 84% rangeland, of which 70% is used for livestock grazing (Fleischner, 1994). Thus, the importance of

livestock production to the regional economy and extensive rangelands as habitat for a suite of predators make Wyoming a state where predator-livestock interactions are relevant

Using retrospective survey data from 274 ranches in Wyoming, Scasta et al. modeled how ranch attributes and large carnivores influenced the timing, duration, and severity of livestock predation. Rangelands characterized as rough, forested, shrubby, or a public grazing allotment reportedly increased predation risk, in part, due to large carnivore exposure. If a predator was nearby, approximately two-thirds of participants noticed livestock nervousness, half of participants noted changes in livestock distribution patterns, and a quarter of participants noted a reduction in livestock grazing time.

The authors suggest that the interaction of large carnivore activity, behavior change, and nonlethal losses may also promote negative feedback loops in which large carnivore activity delays and extends the livestock birth season, ultimately extending the duration of predation, which continues to further exacerbate parturition management. The authors conclude that understanding predator-livestock interactions relative to ranch and rangeland features, parturition, large carnivore exposure, and losses that extend beyond mortalities can assist in developing novel strategies to mitigate lethal and nonlethal losses.

Schwartz CC, Haroldson MA, White GC. 2010. Hazards Affecting Grizzly Bear Survival in the Greater Yellowstone Ecosystem. *Journal of Wildlife Management* 74(4):654-67. DOI:10.2193/2009-206

During the past two decades, the grizzly bear population in the Greater Yellowstone Ecosystem has increased in numbers and expanded in range. Early efforts to model grizzly bear mortality were principally focused within the Fish and Wildlife Service Grizzly Bear Recovery Zone, which currently represents only about 61% of known bear distribution in the GYE.

A more recent analysis that explored one spatial covariate that encompassed the entire GYE suggested that grizzly bear survival was highest in Yellowstone National Park, followed by areas in the grizzly bear Recovery Zone outside of the park, and lowest outside of the Recovery Zone. Although management differences within these areas partially explained differences in grizzly bear survival, these simple spatial covariates did not capture site-specific reasons why bears die at higher rates outside the Recovery Zone.

Using recent data (1983-2003) from radio-marked bears, Schwartz et al. examined grizzly bear mortality in the GYE in an effort to better understand drivers of bear mortality and their relationship to landscape features (i.e., foods, land management policies, human disturbance factors). They found that survival of independent (age ≥2 years) grizzly bears was best explained by the level of human development on the landscape within their home range. Bear survival improved as secure habitat and elevation increased, but declined as road density, number of homes, and site developments increased. Also of note: bears living in areas open to fall ungulate hunting suffered higher rates of mortality than bears living in areas closed to hunting.

Schwartz et al.'s analysis highlights the significance of human activity in terms of predicting bear mortality. Conservation efforts will hinge, to large extent, on mitigating those human factors. Mature whitebark pine is declining in the GYE. Grizzlies will likely increase their use of lower-elevation habitats, where mortalities are typically higher because lower-elevation habitats tend to be more developed with higher human traffic, with associated hazards. The authors recommend that land-management agencies focus on these low-elevation habitats to maintain or improve security for bears.

Schwartz C, Haroldson M, White G, Harris R, Cherry S, Keating K, Moody D, Servheen C. 2006. Temporal, Spatial, and Environmental Influences on the Demographics of Grizzly Bears in the Greater Yellowstone Ecosystem. *Wildlife Monographs* 161:1-68

Grizzly bear populations have increased numerically and spatially over the past two decades. Understanding the temporal, environmental, and spatial variables responsible for this change will help in terms of identifying beneficial management and conservation efforts. Schwartz et al. explored the relationship between demographic vigor and an array of individual, temporal, and spatial covariates.

Overall, changes in survival and reproduction in the Greater Yellowstone Ecosystem (GYE) were influence by 3 principal factors: humans killing bears, changes in food abundance, and density-dependent factors affecting reproduction and survival of dependent young.

Schwartz et al.'s best models indicated that reproductive output, measured as cubs per litter, was most strongly influenced by indices of population size and whitebark pine cone production. Their data suggest a possible density-dependent response in reproductive output. Cub and yearling survival were most affected by residency in the GYE. Survival was highest for cubs and yearlings living outside Yellowstone National Park (YNP) but within the Grizzly Bear Recovery Zone (RZ). Cubs and yearlings living inside YNP had lower survival rates, and those living outside the RZ had the lowest survival rates. Survival rates were negatively related to a population index, suggesting density dependence. Survival improved with higher whitebark pine seed production, greater winter severity, larger litter size, and older mothers.

Most known mortalities (85.5%) were human caused. Best models indicated that females survived better than males, survival was lowest during autumn, and survival increased during years with good whitebark pinecone production. Indices of winter severity, ungulate biomass, and population size, plus individual covariates, including presence of dependent young, prior conflicts with humans, and age class were not important predictors of survival in the authors' models.

Schwartz et al. highlight that grizzly bears will require careful and adaptive management efforts, even if/as specific regulations and agency responsibilities change.

Seoraj-Pillai N, Pillay N. 2017. A Meta-Analysis of Human-Wildlife Conflict: South African and Global Perspective. *Sustainability* 9:34. DOI:10.3390/su9010034

Human–wildlife conflict (HWC) due to competition for shared natural resources between people and wildlife, influences human's food security and the wellbeing of both people and animals. HWC is a major concern in developing countries, affecting people of different socio-economic classes.

Seoraj-Pillai and Pillay conducted a meta-analysis of the occurrence of published scientific reports from 1994 to 2015 on HWC globally and in South Africa particularly to identify vulnerable human communities and their farming practices in developing and developed countries, and vulnerable wildlife guilds. They found that local communities (people living contiguous with protected natural areas) and commercial farmers jointly experienced the highest HWC incidences compared to subsistence farmers, possibly due to reporting bias for commercial farmers. Rural people in Africa and Asia experienced conflict with a diversity of mammals, confirming our expectation that developing countries could potentially experience regular encounters with wildlife. South Africa had more HWC cases than

developed countries (e.g., in Australia and North America), yet the dichotomy between first world and third world economies in South Africa provides a regional exemplar of global patterns in HWC. Globally, HWC involved mainly mammals and birds, with carnivores and primates as the most high-scale conflict species and therefore a severely persecuted group.

The authors state that their foundational research provides the first global assessment of HWC and shows that people in developing countries are vulnerable to HWC, perhaps related to reduced protection of livestock and crops against a larger guild of problem mammals. They suggest that a wider range of literature, including governmental and non-governmental publications, be surveyed to contribute to further research in this area of study.

Shivik JA. 2006. Tools for the Edge: What's New for Conserving Carnivores. *BioScience* 56(3):253-59.

Predator management requires effective tools to mitigate conflicts with livestock. Disruptive and aversive tools can all be useful. Husbandry practices (shed-lambing and night penning, intensive monitoring of flocks/herds), as well as broader scale decisions about when and where to graze in relation to predators, are well used and time-tested approaches to manage wolf-livestock conflicts.

Shivik focuses his discussion on more novel emerging tools and techniques including disruptive stimuli, delaying habituation to stimulus tools, guarding dogs, electric-shock training collars and electrified fladry, and various forms of physical harassment.

Shivik tabulates the biological and economic efficiency of many of these methods, and stresses the importance of using a diverse suite of tools, targeting methods to the time and place where they will be most effective. Habituating predators through indiscriminate over-application will undermine the effectiveness of any method.

Shivik JA, Treves A, Callahan P. 2003. Nonlethal Techniques for Managing Predation: Primary and Secondary Repellents. *Conservation Biology* 17(6):1531-37.

Primary repellants—like fladry or the newly developed Movement-Activated Guard (MAG)—immediately disrupt a predator's actions. They rely on novelty and are rendered ineffective by exposure, learning, and habituation. In contrast, secondary repellants such as shock collars and less-than-lethal ammunition, rely on animal learning to be effective. They rely on aversive conditioning after a link is established between a behavior and a negative outcome. Some tools—guard dogs and electrified 'turbo' fladry—can function as both primary *and* secondary repellants.

Shivik et al. examined the effectiveness of fladry barriers (flagging interspersed and suspended on a strand of rope or twine) and the MAG on wolf behavior on six wolf territories in Wisconsin. The authors also compared the efficacy of a primary repellent (the disruptive stimulus device) versus a secondary repellent (electronic shock collars) amongst captive wolves. The disruptive stimulus device kept captive wolves from consuming a food resource, but did not produce an aversion to the resource (e.g., no effectiveness as a secondary repellant). With training collars, logistical and behavioral variability functionally curtailed the authors' ability to condition wolves.

The authors highlight the complexity of applying nonlethal predation management techniques. Some quite effective tools are relatively complex, expensive, and require high amounts of upkeep. By definition, disruptive tools require selective and targeted use, which entails extra time spent in planning and deployment. It can likewise be difficult to aversively condition predators in real-world situations, precisely because it is hard to control the specificity of the aversion that is entrained (e.g., a bear shot by a rubber bullet may develop aversion to the person who shot it, but not the food resource it was using when it was shot). Shivik et al. suggest that this points to the favorability of utilizing a broad suite of nonlethal tools, tailoring individual management actions to the specific context.

Slagle K, Bruskotter JT, Singh AS, Schmidt RH. 2017. Attitudes Toward Predator Control in the United States: 1995-2014. *Journal of Mammalogy* 98(1):7-16. DOI:10.1093/jmammal/gyw144

Predator control policies in the United States shifted in the latter half of the 20th century, largely in response to public outcry. However, few studies have assessed attitudes toward predator control at the national level.

Slagler et al. replicated measures from a 1995 study that assessed attitudes toward predator management in the United States to determine if public support for predator management and perceptions of the humaneness of specific management practices changed over the past 2 decades.

The authors found relatively minor shifts in attitudes toward predator management, but many of the management practices assessed were rated significantly less humane than in the previous survey. Respondents were generally supportive of predator management aimed at losses of agricultural or private property; however, nonlethal methods were perceived to be far more humane than lethal methods. They suggest that the public is generally supportive of predator control, but increasingly skeptical of the methods employed in control actions.

Slagle K, Bruskotter J, Wilson R. 2012. The Role of Affect in Public Support and Opposition to Wolf Management. *Human Dimensions of Wildlife* 17:44-57. DOI:10.1080/10871209.2012.633237

Individuals process information through two systems: the experiential system, containing affect and emotion, and the analytic system, containing logic and normative rules. Ideally, wildlife management decisions should be based on thoughtful deliberation of facts (i.e. analytic); however, this idea assumes people are capable of turning off their emotions. Objectivity in information processing and decision-making is ideal for natural resource management agencies; however, the idea that one can divorce emotion and other biases from decisions is not consistent with the prevailing scientific evidence.

In this Internet survey, Slagle et al. studied motivated, informed individuals to investigate the role of both systems in wolf recovery policy choices. The authors focused on how a person's affective or emotional reaction to wolves impacts their decisions about wolf conservation efforts.

As the authors predicted, affect played a significant role in people's opinions on wolf recovery and conservation. They found individuals who participated in political activities were most likely to be those driving the policies regarding wolf management, and these individuals appeared to be heavily influenced by their negative or positive reaction to wolves. Responses reflecting intolerance toward wolves are driven by negative affect slightly more than those intentions reflecting stewardship are driven by

positive affect. Slagle et al. found that beliefs about positive and negative outcomes were a greater direct driver for intentions to support than oppose wolf recovery.

Slagle K, Zajac R, Bruskotter J, Wilson, R, Prange S. 2012. Building Tolerance for Bears: A Communications Experiment. *Journal of Wildlife Management and Wildlife Monographs* 77(4):863-69.

Reducing human-bear conflicts and promoting public acceptance for bears is critical for establishing viable, robust bear populations. The public typically favors educational materials concerning bears rather than more aggressive management actions such as lethal control when it comes to wildlife management. Because of this, education as an intervention strategy is often a priority for wildlife managers in order to increase acceptance of wildlife, including black bears. Additionally, educational methods are less controversial, making them more appealing to wildlife managers because they have the potential to reduce or even eliminate the root cause of human-bear conflicts.

There is extensive research on wildlife acceptance capacities (WAC), showing that the acceptability of carnivore populations is often determined by the perceived risks and benefits of the species, as well as individual perceived control over potential conflict and the associated consequences. However, little research has been done on education efforts designed to directly manipulate the variables known to affect an individual's acceptance of a species.

Slagle et al. evaluated the use of educational efforts to increase acceptance of black bears to determine if acceptance increased with information to increase an individual's perception of benefits associated with bear populations, and perception of control over black bear encounters. The authors found that messages including only basic bear biology and behavior information or descriptions of the actions one can take to avoid conflict (which is generally the information found in education outreach materials) are not sufficient for promoting acceptance of bears. They found that only providing information about how best to avoid conflict may decrease acceptance. Further, they found information about the benefits of black bears increased acceptance among study participants; the largest change in acceptance resulted from communications that presented both the benefits of bears as well as the actions people can undertake to avoid conflicts in the first place.

Slagle et al. suggest including only benefits information without information about the actions one can take to reduce conflicts may increase acceptance but can be harmful, especially in areas where bear populations are robust and encounters more likely. They explain it is critical to provide people with the information necessary to reduce their risk of conflict, and conclude that it would be beneficial for wildlife managers to include information about the benefits of bears in educational materials.

Smith DW, Bangs EE, Oakleaf JK, Mack C, Fontaine J, Boyd D, Jimenez M, Pletscher DH, Niemeyer CC, Meier TJ, Stahler DR, Holyan J, Asher VJ, Murray DL. 2010. Survival of Colonizing Wolves in the Northern Rocky Mountains of the United States, 1982-2004. *Journal of Wildlife Management* 74(4):620-34. DOI:10.2193/2008-584

After a roughly 60-year absence, wolves immigrated (1979) and were reintroduced (1995-96) into the Northern Rocky Mountains (NRM), where they were protected under the Endangered Species Act. Smith et al. used hazard models to assess wolf mortality risk in three wolf populations (central Idaho, northwest Montana, and Greater Yellowstone) to assess biological, habitat, and anthropogenic factors

contributing to wolf mortality risk and whether federal protection was adequate to provide acceptably low hazards.

The authors found an overall annual survival rate of 75%, which is generally considered adequate for wolf population sustainability. Most recorded mortalities were human-caused (management removal, illegal take, etc.). Wolves whose territory contained abundant agricultural and private land as well as livestock had higher mortality risk than those that did not. Mortality risk was higher in northwest Montana, likely due to a lower proportion of high quality habitat on secure public land. Lower observed hazard in Greater Yellowstone and central Idaho were likely due to larger high-quality core habitat areas with more explicit protections and/or limited human presence.

These factors (and others not listed here) all highlight the significance of human-caused mortality in the recovering NRM populations. This is especially true in NW MT, although hazard to wolves will likely increase in central ID or Greater Yellowstone if human use/access increases there as well. Glacier National Park and the greater Bob Marshall Wilderness Area do not seem to function as a large refugium from which wolves can emigrate to the surrounding area. This underscores the significance of improving survival rates in northwest Montana by reducing conflicts and illegal killing. The authors advocate for harvest regulations that enhance opportunities for natural dispersal between recovery areas, particularly linkages with Greater Yellowstone.

Smith ME, Linnell JDC, Odden J, Swenson JE. 2000. Review of Methods to Reduce Livestock Depredation: I. Guardian animals. *Acta Agriculturae Scandinavica*, Section A – Animal Science 50(4):279-90

It is important to distinguish livestock guarding dogs (LGDs) from herding dogs. They are bred for different purposes and display distinct physical and behavioral characteristics that dispose them to their job. Most LGDs in use today are Eurasian breeds. As opposed to past centuries, LGDs today usually operate more-or-less independent of the herder (an artifact of less time spent monitoring livestock). As such they must be exceptionally well-bonded with livestock, which presents some unique training challenges.

Reported effectiveness of LGDs varies. It is also typically difficult to attribute depredation reductions to them alone, as LPDs are typically used in conjunction with other management tools and predation behaviors are exceedingly complex. Nevertheless, the majority of producers using dogs consider them an economic asset. They are reportedly effective in deterring bears and felids, as well as other canids.

LDGs can reduce predation and labor (i.e. producers may no longer need to confine or corral sheep nightly, sheep graze in a tighter flock and are easier to monitor). If night confinement is discontinued, pastures can be utilized more efficiently. They also allow for greater peace-of-mind and increased self-reliance in managing predator problems.

Although many problems associated with LGDs are minor and/or rare, LGDs do occasionally harass or kill livestock, stray and not guard livestock, act aggressively toward people, or interfere with herd dogs. LGDs cost money and require time and effort to train and supervise. They are subject to illness and premature death. Incorporation of a guarding-dog system can also cause reduced growth in livestock (stress induced) until they are accustomed to the presence of the dogs.

Smith et al. suggest that LGDs can be a viable management tool, especially when combined with other husbandry practices designed to mitigate depredation risk.

Snijders L, Greggor AL, Hilderink F, Doran C. 2019. Effectiveness of Animal Conditioning Interventions in Reducing Human–Wildlife Conflict: a Systematic Map Protocol. *Environ Evid* 8(1):10. DOI:10.1186/s13750-019-0153-7

Human–wildlife conflict (HWC) is currently one of the most pressing conservation challenges. HWC often involves wild animals consuming anthropogenic resources, such as crops or livestock, either out of necessity (loss of habitat and natural prey) or as consequence of opportunistic behavior.

A variety of interventions are undertaken to reduce HWC, differing in practicability, costs and social acceptance. One such non-lethal intervention is animal conditioning, a technique to reduce conflict by modifying the behavior of 'problem' animals long-term. Conditioning changes associations animals have with resources or behaviors. Both via 'punishment' of unwanted behavior and 'rewarding' of alternative behavior, researchers aim to make expression of unwanted behavior relatively less desirable to animals. Despite the potential, however, studies testing conditioning interventions have reported seemingly contradictory outcomes.

To facilitate reduction of HWC via conditioning, Snijders et al. believe it is necessary to better understand if and when conditioning interventions are indeed effective. With their systematic map, the authors intend to make the global evidence base for conditioning of free-ranging vertebrates more accessible to practitioners, to identify potential evidence clusters and effect modifiers for a subsequent systematic review and to highlight evidence gaps for future research.

Sommers AP, Price CC, Urbigkit CD, Peterson EM. 2010. Quantifying Economic Impacts of Large-Carnivore Depredation on Bovine Calves. *Journal of Wildlife Management* 74(7):1425-34. DOI:10.2193/2009-070

One factor that may account for public resistance to carnivore recovery efforts is the inadequacy of compensation programs for livestock depredations. Developing compensation programs that fairly reimburse livestock producers for losses is, therefore, a necessary component of carnivore recovery efforts.

Sommers et al. examined grazing records and losses from the Upper Green River Cattle Allotment in western Wyoming between 1990 and 2004 in order to quantify the economic impacts of grizzly bear and gray wolf depredation on calves.

Their analysis suggests a compensation factor of 3.8:1 for grizzly depredation, meaning that for every 3.8 calves lost to grizzly bear depredation, only 1 was confirmed. The compensation factor for gray wolf depredation was even higher, at 6.3:1. The authors estimated the uncompensated financial impacts from grizzly bear and gray wolf calf losses on the allotment from 1995-2004 to be as much as $222,500.

The introduction and expansion of large carnivores into grazing allotments has financial impacts on livestock operators because of increased depredation incidents. Sommers et al. argue that a disproportionate share of the cost of predator recovery programs fall on these individuals, and that adequate compensation programs can help address this issue.

Sponarski CC, Semeniuk C, Glikman JA, Bath AJ, Musiani M. 2013. Heterogeneity among Rural Resident Attitudes Toward Wolves. *Human Dimensions of Wildlife* 18(4):239-48. DOI:10.1080/10871209.2013.792022

Rural communities are often considered a homogeneous population in resource management, and wolf management is no exception. However, the increasing migration of residents into rural areas has created the potential for conflicts about land use and differing attitudes about natural resource management.

Sponarski et al. conducted a survey in southwestern Alberta to gather data regarding attitudes toward wolves and fear, and wolf management. They found that multiple attitudes exist in the region regarding wolves and wildlife management; attitudes that indicate greater diversity than previously thought in how the public feels about wolves on the landscape.

The study was conducted in three rural municipal districts—Foothills, Pincher Creek, and Willow Creek— a landscape characterized by rural settlements and converted open land utilized for livestock production and agriculture.

Consistent with other international findings (Glikman, Bath, & Vaske, 2010), the results suggested the rural population is not a homogenous attitudinal group. The differences between groups were meaningful and definable by different socio-demographic information such as whether a person was a livestock producer or a hunter, and by sex and education level.

Steele JR, Rashford BS, Foulke TK, Tanaka JA, Taylor DT. 2013. Wolf (*Canis lupus*) Predation Impacts on Livestock Production: Direct Effects, Indirect Effects, and Implications for Compensation Ratios. *Rangeland Ecol Manage* 66:539-44. DOI:10.2111/REM-D-13-00031.1

Controversy over the reintroduction of wolves remains a frequent newspaper headline across the US Rocky Mountain region, much of it stemming from wolf depredation of livestock, which has steadily increased since reintroduction in 1995 (e.g., USFWS 2011). Given that the costs of large carnivore conservation are disproportionately borne by local livestock producers, the United States uses compensation for wolf damage to reduce conflicts and mediate negative attitudes toward the predators (Schwerdtner and Gruber 2007, Dickman et a. 2011).

Thought their ability to achieve conservation goals has been questioned (Boitani et al. 2010), designing effective compensation schemes requires a more thorough accounting of the costs—direct and indirect—large carnivores impose on livestock producers.

Using a stochastic budget model of a representative cow-calf operation in northwestern Wyoming, Steele et al. estimated the economic impact of both direct (death loss and injured calves) and indirect (decreased weaning weights, decreased conception rates, and increased cattle sickness) effects.

Their results suggest that short-run (year-to-year) financial impacts of indirect effects may be as large as or larger than direct effects. Steele et al. argue that including indirect effects implies that the compensation ratio necessary to fully offset financial impacts of wolves would need to be two to three times larger than the current compensation ratio used in Wyoming.

Stenglein JL, Wydeven AP, Van Deelen TR. 2018. Compensatory Mortality in a Recovering Top Carnivore: Wolves in Wisconsin, USA (1979-2013). *Oeacologia* 187(1):99-111. DOI:10.1007/s00442-018-4132-4

Understanding annual survival rates and their dependence on interacting causes of mortality in wildlife populations informs researchers and managers about population growth potential, setting of harvest quotas, and effects of age, sex, environmental variables, population responses to management actions, and other covariates. Assessing survival and cause-specific mortality as a function of time and space broadens our understanding of survival in a wildlife population with extensions to identifying sources and sinks, areas of conservation need, management zone delineation, timing of harvest seasons, and periods of reduced survival.

Stenglein et al. analyzed gray wolf mortality in Wisconsin from recolonization through the first years of recreational harvest (1979-2013) to provide critical information about where and when wolves experience variable hazard rates from different mortality sources. The authors found that mean annual survival was 76% and mean annual causes of mortality were illegal killing (9.4%), natural and unknown causes (9.5%), and other human-caused mortality such as hunting, vehicle collisions, and lethal control (5.1%). Illegal killing and natural mortality were highest during winter, causing wolf survival to decrease relative to summer.

The authors suggest that assessments of wolf survival and cause of mortality rates and the finding of partial compensation in mortality sources will inform wolf conservation and management efforts by identifying sources and sinks, finding areas of conservation need, and assessing management zone delineation.

Stewart BP, Nelson TA, Laberee K, Nielsen SE, Wulder MA, Stenhouse G. 2013. Quantifying Grizzly Bear Selection with Natural and Anthropogenic Edges. *Journal of Wildlife Management* 77(5):957-64. DOI:10.1002/jwmg.535

As edges represent the interface between distinct habitat patches, unique ecosystem characteristics may occur near them (Forman 1995, Fortin et al. 2000, Ries et al. 2004). Creation of edge habitat can increase mortality as species may be exposed to greater rates of predation (Gardner 1998, Nielsen et al. 2004b) and brood parasitism (Murcia 1995). However, edges may also improve habitat conditions by providing access to resources in distinct habitat patches in close proximity (Lay 1938, Forman 1995, Ries and Sisk 2004).

Stewart et al. studied grizzly bear habitat selection in relation to different landscape-level measures of edge, both natural and anthropogenic, using a database of GPS telemetry data from 2005 to 2009, from the foothills if the Rocky Mountains in west-central Alberta.

The authors found that in general females selected anthropogenic edges, whereas males selected natural edges. Both sexes selected the natural transition of shrub to conifer. Females had a greater selection ratio for road edges than males in all seasons, and males had a greater selection ratio for roads in the fall than in other seasons

Stewart et al. suggest that, given human access to bear habitat is often facilitated by anthropogenic

edges, improved management of these features may minimize human conflicts. In particular, they highlight the importance of natural transition from shrub to conifer to grizzly bears.

Stone SA, Breck SW, Timberlake J, Haswell PM, Najera F, Bean BS, Thornhill DJ. 2017. Adaptive Use of Nonlethal Strategies for Minimizing Wolf-Sheep Conflict in Idaho. *Journal of Mammalogy* 98(1):33-44. DOI:10.1093/jmammal/gyw188

While livestock losses to wolves represent a small fraction of overall livestock mortality, the response to these depredations has resulted in widespread conflicts including significant efforts at lethal wolf control to reduce impacts on livestock producers, especially those with large-scale grazing operations on public lands. A variety of nonlethal methods have proven effective in reducing livestock losses to wolves in small-scale operations but in large-scale, open-range grazing operations, nonlethal management strategies are often presumed ineffective or infeasible.

To demonstrate that nonlethal techniques can be effective at large scales, Stone et al. conducted a 7-year case study in which they strategically applied nonlethal predator deterrents and animal husbandry techniques on an adaptive basis to protect sheep and wolves on public grazing lands in Idaho. They collected data on sheep depredation mortalities in the protected demonstration study area and compared these data to an adjacent wolf-occupied area where sheep were grazed without the added nonlethal protection measures.

The authors found that sheep depredation losses to wolves were higher in the Nonprotected Area (NPA) than in the Protected Area (PA). Furthermore, no wolves were lethally controlled within the PA and sheep depredation losses to wolves were the lowest loss rate among sheep-grazing areas in wolf range statewide. Wolves were lethally controlled in the NPA. They suggest that proactive use of a variety of nonlethal techniques applied conditionally can help reduce depredation on large open-range operations.

Suzuki N, Parker KL. 2016. Potential Conflict Between Future Development of Natural Resources and High-Value Wildlife Habitats in Boreal Landscapes. *Biodivers Conserv* 25: 3043-73. DOI:10.1007/s10531-016-1219-2

Conservation of intact ecosystems to sustain populations of species and biodiversity has become increasingly urgent as the human population worldwide continues to increase, seeking room for expansion into previously undeveloped wild lands and new opportunities for extraction of natural resources to satisfy ever increasing demands (Wittemyer et al. 2008; Leroux and Kerr 2013; Geldmann et al. 2014).

For a long time, boreal lands were protected from resource development because of harsh climate, remoteness, and inaccessibility (Andrew et al. 2012, 2014). Now, cumulative effects from increasing development of multiple resources, such as timber, oil and gas, hydroelectric dams, and mining, have begun to alter compositions of biological communities largely because of habitat loss (Venier et al. 2014). Among wildlife in Canada's boreal zone, population declines and range contractions are pronounced for woodland caribou and grizzly bears; some populations have been extirpated near the southern border of the boreal zone (Venier et al. 2014). Despite the ongoing threats to biodiversity from various resource developments, current status of ecosystem health in the boreal zone has not been

assessed fully because long temporal and broad spatial biological and ecological datasets as well as coordinated research efforts are lacking (Kreutzweiser et al. 2013).

Suzuki and Parker explored potential conflicts between future resource development and high-value habitats of large mammals in an undeveloped boreal landscape in northeast British Columbia. They found that greater proportions of high-value habitats for moose, elk, and wolves overlapped areas of high cumulative resource potential, and impacted both winter and the growing season. The authors recommend a quantitative and visual GIS approach to scenario planning in the region to maintain abundance and diversity of wildlife populations.

Sweanor LL, Logan KA, Hornocker MG. 2000. Cougar Dispersal Patterns, Metapopulation Dynamics, and Conservation. *Conservation Biology* 14(3):798-801.

Cougars once ranged throughout North America, but by the turn of the 20th century, humans had virtually extirpated cougars in eastern North America and, in the West, relegated them to the most remote habitats (Young 1946, Nowak 1976). Recent recovery of the cougar throughout much of its western range can be attributed to regulated hunting of the species since the mid-1960s, the presence of large tracts of relatively undisturbed habitat, and pathways for dispersal.

Sweanor et al. examined cougar dispersal, emigration, and immigration in the San Andres Mountains, New Mexico, to quantify the effects of dispersal on the local population and surrounding subpopulations. They found that cougars in southern New Mexico exhibited a metapopulation structure in which cougar subpopulations were separated by expanses of non-cougar habitat and linked by dispersers. Males were observed to disperse significantly farther than females, were more likely to traverse large expanses of non-cougar habitat, and were probably the most responsible for nuclear gene flow between habitat patches.

Sweanor et al. suggest that protected cougar subpopulations can contribute to metapopulation persistence by supplying immigrants to surrounding subpopulations that are affected by fragmentation or offtake by humans. The authors argue that cougar population dynamics and dispersal behavior dictate that cougar management and conservation should be considered on a regional scale. They recommend that agencies managing cougars in fragmented habitats need to identify and map subpopulations that are sources, sinks, and vulnerable to extinction because of small size or poor connectivity. Long-term monitoring could help managers determine how human offtake will affect metapopulation dynamics and how development may degrade habitat and corridors.

Teichman KJ, Cristescu B, Darimont CT. 2016. Hunting as a Management Tool? Cougar-Human Conflict is Positively Related to Trophy Hunting. *BMC Ecology* 16(44):1-8. DOI:10.1186/s12898-016-0098-4

When conflicts involve large mammalian predators that pose a perceived or real threat to humans and property, a common outcome is the lethal removal of the predator by management agencies, landowners, and/or hunters. In the case of predator-human conflict over depredation, it is suggested that carnivore killing by hunters may actually promote conflict (Treves and Naughton-Treves 2005) because of shifts in age composition (Robinson et al. 2008) and fairly quick recolonization of conflict areas (Conner et al. 1998).

Teichman et al. examined a dataset from 1979 to 2008 on human hunting of cougars and cougar-involved conflict in British Columbia, Canada, to test their young animal, problem animal, and human hunting hypotheses. They found that while some lethal management focused on targeted individuals could be one option for addressing conflicts, overall increases in human hunting can, in fact, be associated with increased conflict, especially for male cougars.

Treves A, Artelle K, Paquet P. 2018. Differentiating Between Regulation and Hunting as Conservation Interventions. *Conservation Biology* 33(2):472-75. DOI: 10.1111/cobi.13211

Preventing species extinction and extirpation requires correct identification of major threats to survival and effective interventions to prevent them. Some believe hunting to be an effective conservation intervention. Predators in particular are targets of this concept due to the hypothesis that people more readily tolerate predator populations when a small subset is hunted.

Siting historical recoveries of American Bison and other species in the early 20th century, Treves et al. counter that regulatory systems limiting participation in hunting and trapping were the defining factor facilitating species recovery. Yet, the perspective that regulation saved wild animals of western nations is persistently misrepresented in management and scientific literature by an interpretation that hunting itself was the intervention.

Elucidating this misconception, the authors argue that the conservation community needs incisive experiments to disentangle the hypothesis that hunting itself protects animals from the competing hypothesis that regulating hunting protects animals.

Treves A, Chapron G, Lopez-Bao JV, Shoemaker C, Goeckner AR, Bruskotter JT. 2015. Predators and the Public Trust. *Biological Reviews* 92(1):248-70. DOI: 10.1111/brv.12227

Environmental movements and strict legal protections have fostered predator recoveries across the U.S. and Europe since the 1970s. Now subnational jurisdictions are regaining management authority from central governments for their predator subpopulations. Will the history of local eradication repeat or will these jurisdictions adopt public trust thinking and their obligation to broad public interests over narrower ones?

Treves et al. reviewed the role of public trust principles in the restoration and preservation of controversial species. They looked beyond species endangerment to future generations' interests in sustainability, particularly non-consumptive uses, and examined how differences between traditional assumptions and scientific studies of interactions between people and predators impede evidence-based policy.

The authors explore many important facets of this topic and concur that without public trust principles, future trustees will seldom prevail against narrow, powerful, and undemocratic interests. Without conservation informed by public trust thinking predator populations will face repeated cycles of eradication and recovery. They suggest that their conclusions have implications for the many subfields of the biological sciences that address environmental trust assets from the atmosphere to aquifers.

Treves A, Jurewicz RL, Naughton-Treves L, Wilcove DS. 2009. The Price of Tolerance: Wolf Damage Payments after Recovery. *Biodivers Conserv* 18(14):4003-21. DOI: 10.1007/s10531-009-9695-2.

The costs of wildlife conservation distribute unequally across society. Compensation can potentially redress inequities and raise local tolerance for endangered wildlife that damage property. However, the rules for payments generate controversy, particularly as costs mount and species recover. In Wisconsin, gray wolf damage payments grew notably over 28 years and eventually undermined budgets for conserving other endangered species. Treves et al. measured attitudes to compensation among 1,364 state residents, including those who voluntarily contributed funds and those likely to receive compensation, and we interviewed elected officials about the politics of payment rules.

Most respondents endorsed compensation for wolf damages to livestock—even when wolves are no longer endangered—but opposed payments for wolf damage to hunting dogs on public land. Most donors opposed killing wolves and more than one-fourth unconditionally rejected a wolf hunt. The authors predict the latter donors would stop contributing funds for compensation if the state were to implement a proposed wolf hunt. Controversy over payment rules reveals clashing values regarding wildlife between those receiving and those paying for compensation. Moreover, compensation costs rachet up as endangered species recover and claims of entitlement expand. The authors recommend conservationists use sunset clauses and an adaptive management of compensation programs.

Treves A, Krofel M, McManus J. 2016. Predator Control Should Not Be a Shot in the Dark. *Frontiers in Ecology and the Environment* 14(7):380-88. DOI:10.1002/fee.1312.

Killing top predators—such as wolves and leopards, which occasionally prey on livestock—has prompted concerns associated with ethical issues (Vucetich and Nelson 2014), effectiveness, and ecological impacts. Depletion of apex consumers has led to degradation of ecosystems and disruption of vial ecological processes worldwide (Estes et al. 2011, Ripple et al. 2014). As a result, traditional nonlethal methods have been reinstated and new approaches are being developed (Treves et al. 2009). However, many lethal and nonlethal methods are implemented without first considering experimental evidence of their effectiveness.

Treves et al. evaluated evidence for interventions against carnivore predation on livestock in North American and European farms, and reviewed a selection of tests from other continents, to assess the global generality of their findings. They found a greater portion of nonlethal methods than lethal methods were effective in preventing carnivore predation on livestock.

Treves et al. recommend that policy makers suspend predator control efforts that lack evidence for functional effectiveness, and that scientists focus on stringent standards of evidence in tests of predator controls.

Treves A, Martin KA. 2011. Hunters as Stewards of Wolves in Wisconsin and the Northern Rocky Mountains, USA. *Society and Natural Resources* 24(9):984-94. DOI:10.1080/08941920.2011.559654.

Hunting advocates often argue that hunters champion conservation and generate revenue for wildlife management. Similarly, well-managed hunts will promote sustained, stable wildlife populations, and lead to reduced conflicts with game species. However, applying these notions to wolves is complicated

by widespread intolerance for the species (as opposed to non-predator game such as ungulates or waterfowl). Treves and Martin used three surveys to assess hunter and non-hunter attitudes toward wolves (spanning 2001-2007, among 2,300 residents of MT, ID, WY, and WI).

The authors found widespread support for a regulated, public hunting season on wolves, albeit with some stipulations about the justifications for such a hunt. Findings did not show that nonhunters will oppose hunting, and supported the assertion that nonhunters endorse hunting as a conflict remedy. For their part, likely wolf hunters showed little inclination to conserve wolves. The majority of hunters were unsupportive of wolf conservation at the time of these surveys. In fact, the authors caution against assuming that hunters will support the conservation of wolves simply because they have done so in the past for other game species. Hunter attitudes may change following the widespread initiation of a wolf hunt, but such an assertion is conjecture at best; there was no basis for supporting that claim.

These surveys suggest nuanced and diverse views on wolf hunting. Less than 17% of respondents unconditionally opposed a hunt. An overall majority endorsed a wolf hunt, but that support was somewhat conditional on how the decision was framed. This reaffirms the complexity of the situation, as well as the significance of social/public discourse in defining 'acceptable' options. Treves and Martin suggest that policymakers should seek to understand the nuances of the stakeholder community if they wish to effectively conserve carnivores and balance human interests.

Treves A, Naughton-Treves L, Harper E, Mladenoff D, Rose R, Sickley T, Wydeven A. 2004. Predicting Human-Carnivore Conflict: a Spatial Model Derived from 25 Years of Data on Wolf Predation on Livestock. *Conservation Biology*. 18(1):114–25.

With the recovery of many large carnivore populations in North America, including the gray wolf and grizzly bear, encounters between carnivores, livestock, and humans are increasing in many areas. As carnivore populations are increasing, their habitat and range are expanding, often into the same areas as humans and domestic animals. Lethal tools such as poisoning, shooting, and trapping carnivores are used in response to human and livestock conflicts with humans. These control methods threaten carnivore conservation, and ultimately undermine the work of the Endangered Species Act of protecting these animals.

Using sites of past wolf attacks on livestock in mixed forest-agriculture landscapes in Wisconsin and Minnesota, Treves et al. present a method to predict sites of human-carnivore conflicts regionally. Previous research has shown that dense vegetative cover appears to favor livestock predation by wolves and other large carnivore; likewise, placing pastures around vegetated waterways may promote coyote predation on sheep. In addition, reports have shown a negative association between carnivore predation on livestock and the density of human roads and settlements.

Treves et al. found that wolf attacks on livestock in Wisconsin and Minnesota were not randomly distributed in space. They discovered wolves preyed on livestock in townships sharing a consistent set of landscape features across both states, despite dramatic differences in the two states' wolf population sizes, wolf control policies, and farm sizes.

The study found that pasture areas were strongly correlated with risk to livestock, likely because of high cattle densities. However, deer also prefer the same areas, so it is also possible wolves were following the deer and encounter cattle incidentally. Finally, Treves et al. found that coniferous forest, herbaceous

wetland, and open water were all associated with lower risk for livestock across matched townships. However, open water and coniferous forest were associated with higher risk across matched farms.

Treves et al. suggest that policymakers and wildlife managers can use maps similar to the ones they used in the study to determine more precise management zones, helping to reduce and mitigate conflicts.

Treves A, Naughton-Treves L, Shelley V. 2013. Longitudinal Analyses of Attitudes Toward Wolves. *Conservation Biology* 27(2):315-23. DOI:10.1111/cobi.12009

Understanding individual attitudes and how they predict overt opposition to predator conservation or direct, covert action against predators will help to recover and maintain populations. Yet, studies of attitudes toward carnivores rely primarily on samples of individuals at a single point in time.

Treves et al. (2013) examined longitudinal change in individuals' attitudes toward gray wolves in Wisconsin through mail-in surveys in 2001, 2004, and 2009. Results indicated that, over time, respondents increasingly agreed with statements reflecting fear of wolves, the belief that wolves compete with hunters for deer, and inclination to poach a wolf. Additionally, support for lethal control of wolf populations by federal and state agencies increased over the study period.

As a result, the authors predict future increases in legal and illegal killing of wolves that may reduce their abundance in Wisconsin unless interventions are implemented to improve attitudes and behavior toward wolves. They further suggest that to assess whether interventions change attitudes, additional longitudinal studies are needed.

Treves A, Rabenhorst M. 2017. Risk Map for Wolf Threats to Livestock Still Predictive 5 Years After Construction. *PLoS ONE* 12(6): e0180043. DOI:10.1371/journal.pone.0180043

Risk maps are predictive models with spatial components that distinguish locations by the probabilities that an environmental hazard occurs there. Risk maps have attracted growing interest in environmental fields and have been utilized to assess hazards such as predation on livestock. To understand the efficacy of risk maps with regard to livestock depredations, Treves et al. quantitatively evaluated the long-term validity of a published risk map built from locations of Wisconsin wolf-livestock attacks from 1996 to 2006.

Using data collected after model construction, the authors verified the predictive accuracy of the risk map exceeded 91% for the period 2007–2011. Predictive power lasting 5 years or more substantiates the claim that risk maps are both valid and verified tools for anticipating spatial hazards. Conclusively, the risk map built with data collected from 1999–2006 continued to accurately predict the locations that might risk wolf attacks on livestock as late as 2011. Moreover, the risk model situated almost half of all incidents in the highest-risk category of pixels, thereby usefully focusing attention on areas of significant predation. The authors state that as doubts grow regarding the effectiveness of killing carnivores as a means of decreasing livestock depredations, managers should focus investment in prevention at high-risk sites. Risk maps present a tool for such targeting.

Treves A, Wallace RB, White S. 2009. Participatory Planning of Interventions to Mitigate Human-Wildlife Conflicts. *Conservation* Biology 23(6):1577-87. DOI:10.1111/j.1523-1739.2009.01242.x

Treves et al. summarize recommendations from the literature pertaining to a range of human-wildlife conflict interventions. They classify these interventions as either direct (reducing severity or frequency of encounters with wildlife) or indirect (raising human tolerance for encounters with wildlife).

The authors attempt to clarify the focal point of intervention for a series of intervention types, and organize their recommendations using three criteria: cost effectiveness; wildlife specificity and selectivity; and sociopolitical acceptability. The authors note that some interventions can lead to diverse outcomes, and as with any management tool effectiveness is highly context-dependent.

The authors used workshops to validate and refine their insights. They argue that conservation actions will be more effective if the relative merits of interventions are evaluated in a case-by-case, systematic, and participatory manner. They argue for optimizing participation in conservation planning. This approach is clearly complicated by the fact that management interventions often engender powerful emotions and may invoke broader sociopolitical interests. Nonetheless, they suggest that participatory planning can generate diverse and highly effective approaches by promoting institutional flexibility and explicitly incorporating local and 'informal' knowledge. Participation in these processes can also raise tolerance for management activities.

Tucker M, Bohning-Gaese K, Fagan W, et al. 2018. Moving in the Anthropocene: Global Reductions in Terrestrial Mammalian Movements. *Science* 359(6374):466-69. DOI:10.1126/science.aam9712

With approximately 50% to 70% of Earth's land surface currently modified for human activities, patterns of biodiversity and ecosystem functions worldwide are changing. The expanding footprint of human activities not only is causing the loss of habitat and biodiversity but is also affecting how animals move through fragmented and disturbed habitats. Animal movement is fundamental for ecosystem functioning and species survival, yet the effects of the anthropogenic footprint on animal movements have not been estimated across species.

Using a unique GPS-tracking database of 803 individuals across 57 species, Tucker et al. found that movements of mammals in areas with a comparatively high human footprint were on average one-half to one-third the extent of their movements in areas with a low human footprint. Analyses determined that carnivores traveled on average farther per unit time than herbivores and omnivores. Further, results concurred with prior understanding that carnivores have larger home range sizes, because they need to find mobile prey and compensate for energy conversion loss through the food web.

The authors argue that future landscape management should strive to maintain landscape permeability by including animal movement as a key conservation metric. Ultimately, because of the critical role of animal movement in human-wildlife coexistence, and disease spread, the effects of reduced mobility may go beyond ecosystem functioning to directly affect human wellbeing.

Ugarte CS, Moreira-Arce D, Simonetti JA. Ecological Attributes of Carnivore-Livestock Conflict. *Frontiers in Ecology and Evolution.* 7:433. doi.org/10.3389/fevo.2019.00433

Carnivore-livestock conflict poses an urgent challenge in landscapes where the requirements of carnivores are often at odds with those of human activities. Understanding the ecological conditions and characteristics of predators involved in carnivore-livestock conflicts is necessary for setting evidence-based management strategies.

Ugarte et al. sought to provide a global perspective of carnivore-conflict research to determine the extent to which carnivore species and their ecological traits are reported in conflict-related literature. They evaluated 391 peer-reviewed research papers containing 783 predation study cases published between 1992 and 2019. Ugarte, Moreira-Arce and Simonetti found that 60% of these studies were conducted in Asian and African countries, and conflicts involving Felidae and Canidae families comprised 80% of all study cases. In addition to identifying patterns in carnivore-livestock conflicts, the authors also noticed gaps in the published studies; for instance, meso carnivores and recently-altered ecosystems were underrepresented in the literature.

The authors suggest that expanding our knowledge of less-studied predators, including meso carnivores, and identifying ecological attributes that distinguish conflict-prone areas may contribute to evidence-based management approaches that can effectively anticipate, reduce, or prevent human-carnivore conflicts.

Urbigkit C, Urbigkit J. 2010. A Review: The Use of Livestock Protection Dogs in Association with Large Carnivores in the Rocky Mountains. *Sheep and Goat Research Journal* 25:1-8.

Livestock protection dogs (LPDs) are widely regarded as a good tool for mitigating wolf and bear conflicts with livestock, but LPDs have seen only limited use in North America. Herding dogs often work in and around flocks of North American sheep, but these breeds (such as the border collie) are distinct in form and function from Eurasian breeds selected specifically for their ability to fight and/or drive away large predators. Urbigkit and Urbigkit provide an overview of each Eurasian breed, its history, and individual advantages.

The authors recommend that LPDs be deployed in groups of two to five, with the objective of outnumbering and outweighing wolves in individual encounters. Individual dogs and breeds will have different behavioral and guarding tendencies, so the proper mix of traits in a group of LPDs will depend of specifics of context and may take time and readjustment.

They authors also discuss spiked collars as a tool to protect the dogs that accompany livestock. Spiked collars have only seen limited use in North America. Attaching iron to dogs when they may be exposed to very low temperatures is a frequent concern, as is the danger of collars becoming entangled in fencing or brush. The authors suggest that these concerns deserve attention so that they can be mitigated through specific design modifications. They argue that spiked collars may allow LPDs to function much more effectively—not only by improving survivability of encounters with predators, but also by deterring inter-pack aggression amongst groups of LPDs.

Urbigkit and Urbigkit argue that LPDs offer high economic efficiency and on-the-ground effectiveness. Some Northern Rockies livestock producers have successfully used these breeds and techniques

developed by nomadic pastoral Eurasian cultures; wildlife management efforts would benefit from a more full incorporation of this range of tools. The authors recommend their incorporation into wildlife conflict management efforts in the Western U.S.

Van Eeden L, Crowther M, Dickman C, MacDonald D, Ripple W, Ritchie E, Newsome T. 2017. Managing Conflict Between Large Carnivores and Livestock. *Conservation Biology* 32(1):26-34. DOI:10.1111/cobi.12959

Large carnivores are persecuted globally because they threaten human industries and livelihood. How this conflict is managed has consequences for the conservation of large carnivores and biodiversity more broadly. Mitigating human-predator conflict should be evidence-based and accommodate people's values while protecting carnivores. Despite much research into human and large carnivore coexistence strategies, there have been few attempts to document the success of conflict-mitigation strategies on a global scale.

Van Eeden et al. conducted a meta-analysis of global research on conflict mitigation related to large carnivores and humans, extracting relevant data from studies to calculate an overall effect size for differing lethal and nonlethal intervention types. The results indicated livestock guardian animals most effectively reduced livestock losses, while lethal control was the second most effective control, although its success varied significantly.

The authors argue that these results indicate that nonlethal management can be more or just as effective as lethal control, suggesting that coexistence with large carnivores is possible in mixed use landscapes. To increase the efficacy of nonlethal management, the authors then suggest coexistence strategies be location-specific, incorporate cultural values and environmental conditions, and be designed such that return on financial investment can be evaluated.

Van Eeden L, Eklund A, Miller J, López-Bao J, Chapron G, Cejtin MR, Crowther MS, Dickman CR, Frank J, Krofel M, Macdonald DW, McManus J, Meyer TK, Middleton AD, Newsome TM, Ripple WJ, Ritchie EG, Schmitz OJ, Stoner KJ, Tourani M, Treves A. 2018. Carnivore Conservation Needs Evidence-Based Livestock Protection. *PLoS Biology* 16(9): e2005577. DOI:10.1371/journal.pbio.2005577

Carnivore predation of livestock often leads to human-induced mortality for the predator, which has contributed to global endangerment of carnivores. Preventing livestock losses would help to achieve three goals common to many human societies: preserve nature, protect animal welfare, and safeguard human livelihoods. Balancing these goals necessitates policies that foster coexistence between humans and carnivores in multi-use landscapes. Central to this aim is a need for rigorous scientific evidence that assesses which interventions are effective in preventing predation on livestock.

Van Eeden et al. evaluated 27,000 scientific studies assessing effectiveness of predator control methods over a 40-year period, of which 114 studies were prioritized for their scientific efficacy and attributes consistent with selection criteria (geographic coverage, carnivore species, and standards of evidence and research design). The majority of studies they assessed lacked quantitative comparisons of interventions and had few comparisons against experimental controls. These limiting factors negatively affect various research design models and methods and minimize the scalability and application of these studies' conclusions.

The authors argue the need for a comprehensive evidence base that allows comparison of the effectiveness of interventions for reducing carnivore predation on livestock and can inform consistent policy in any jurisdiction. They additionally recommend that a coalition of scientists and managers be formed to establish and encourage use of consistent standards in future experimental evaluations.

Vernon ME, Bischoff-Mattson Z, Clark SG. 2016. Discourses of Elk Hunting and Grizzly Bear Incidents in Grand Teton National Park, Wyoming. *Human Dimensions of Wildlife* 21(1):65-85.
DOI:10.1080/10871209.2016.1099766

The Grand Teton National Park (WY) annual elk hunt, or elk reduction program, was legislated in 1950 to resolve a dispute over whether the federal or state government should have authority over wildlife management on Wyoming's public lands. The program allows joint management of the GTNP elk by the National Park Service and the Wyoming Fish and Game Department—the former mandated to preserve and protect natural resources, and the latter expected to conserve the state's wildlife and manage game species for hunting. The success of these approaches has been mixed, and there continues to be stakeholder disagreement over their appropriateness—the feed grounds and park elk hunt are both highly controversial, and calls for their termination have persisted for decades (Clark 2000, Smith 2012, Wilbrecht and Robbins 1979).

Vernon et al. analyzed opinion-editorials over an approximately two-year span and conducted 35 interviews in summer 2013 to examine how participants defined problems, used evidence, and advocated solutions in relation to two conflict incidents between hunters and grizzly bears during the elk hunts in 2011 and 2012. Their incident analysis found fundamental differences in public and agency expectations about the GTNP elk hunt and other regional wildlife management issues. These differences underlie persistent conflict over the park elk hunt and Jackson Hole, WY, elk management practices, and they fuel criticism of agencies challenged with the difficult task of jointly managing these resources.

Vernon et al. recommend a full appraisal of the hunt to clarify common interests among the different perspectives discussed therein, as well as substantive action to address them including development of a more inclusive decision-making process.

Vijayan S, Morris DW, McLaren BE, Mukherjee S. 2017. Domestic Ungulates in Protected Areas and the Potential for Indirect Interactions Via Shared Predation. *Biodiversity* 18(4):129-36.
DOI:10.1080/14888386.2017.1406405

Studies dealing with livestock in protected areas have primarily focused on interactions such as competition for food resources with native herbivores, habitat degradation, and human-carnivore conflicts caused by livestock depredation. The negative effects of such interactions are a major threat to the survival of many mammalian prey and predator species. However, the role of indirect interactions between native herbivores and domestic prey, via their common enemy, has received comparatively little attention and poses a significant knowledge gap in understanding the net impacts of domestic prey on native herbivores.

Vijayan et al. reviewed research publications dealing with livestock-mediated interactions and found that more attention was given to human-wildlife conflict than to all other categories combined. Wildlife

invariably loses in encounters with humans and 21 carnivore species are threatened by human–carnivore conflicts associated with livestock predation (IUCN Red List). Financial compensation for livestock loss is a typical response, despite social determinants playing a greater role in attitudes toward carnivores. Studies focused on predation ecology in livestock systems often concentrate on quantifying the proportional contribution of each prey species, domestic and native, to the diet of the predator. This approach does not assess the possibility of livestock-mediated indirect interactions via shared predation. For example, increased grazing in a particular habitat by domestic prey may attract predators to that area, which in turn can affect habitat selection by other wild ungulate prey in the system.

The authors argue that failure to consider the indirect interactions that are mediated by a common predator, can lead to incomplete understanding of foraging decisions by prey animals and the resulting net interactions among prey. They make a case for conservation to include a range of predator-mediated indirect interactions that are missed or ignored in livestock-dominated systems.

VonHoldt BM, Stahler DR, Bangs EE, Smith DW, Jimenez MD, Mack CM, Niemeyer CC, Pollinger JP, Wayne RK. 2010. A Novel Assessment of Population Structure and Gene Flow in Grey Wolf Populations of the Northern Rocky Mountains of the United States. *Molecular Ecology* 19:4412-27.

The long-term success of Northern Rocky Mountain (NRM) wolf recovery efforts will depend at least in part on the genetic structure and connectivity of subpopulations, along with the preservation of genetic variation. VonHoldt et al. analyzed DNA samples from Northern Rocky Mountain wolves from the three NRM recovery areas (Greater Yellowstone, Montana, and Idaho; 1995–2004) and found that the population appeared to maintain high levels of variation—with low levels of inbreeding—throughout the study period.

The authors detected genetically effective dispersal among the three recovery areas. Genetic diversity was high throughout the study period. Lower observed levels of genetic variation in Montana were probably attributable to its small population size relative to the other recovery areas. Inbreeding coefficients were low, and overall results imply that genetic variation was maintained in the NRM wolf populations during the study. Despite the close proximity of regional subpopulations within established dispersal capabilities of wolves, population divergence seems to have increased toward the end of the study period.

This genetic differentiation is likely influenced by anthropogenic factors. While high-quality core habitat exists throughout much of the NRM study area, high human and livestock densities, as well as greater human access, characterize the areas surrounding and connecting each recovery area. Regional-scale study of survival and mortality for NRM wolves have shown increased mortality risk for yearlings, dispersers, and wolves living in areas of overlap with private land and livestock. These demographic and spatial dynamics, which are largely driven by anthropogenic factors, may be critical to the metapopulation dynamics of NRM wolves in the future, as they influence rates of natural dispersal and genetic connectivity between recovery areas.

VonHoldt et al. note that successful conservation of NRM wolves will rely on management decisions that promote natural dispersal dynamics and minimize anthropogenic factors that reduce genetic connectivity.

Vucetich JA, Bruskotter JT, Nelson MP, Peterson RO, Bump JK. 2017. Evaluating the Principles of Wildlife Conservation: A Case Study of Wolf (*Canis lupis*) hunting in Michigan, United States. *Journal of Mammalogy* 98(1):53-64. DOI:10.1093/jmammal/gyw151

The considerations that arise in addressing the appropriateness of predator control vary greatly with context, such as species, the extent of impacts, and the justifications provided for control. Because considerations vary, it may be impossible to conclude that predator control is universally wrong or universally acceptable—in other words, the appropriateness of predator control likely depends on the details of each case.

In Michigan, wolves were removed from the list of United States endangered species in December 2011. By June 2013, plans had been finalized to begin hunting wolves in fall 2013. According to these plans, a purpose of the hunt was to reduce wolf abundance in particular regions of Michigan to reduce threats to livestock and human safety.

Vucetich et al. evaluated the hunting plans using two basic tenets of wildlife management—the North American Model of Wildlife Conservation's seven principles and the clarity, capacity to meet, and appropriateness of the management action's purpose or goal. The authors found that plans for hunting wolves in Michigan appeared not to meet the principles of either tenet, and suggest that either wolf hunting as it has been planned in Michigan is inappropriate or both sets of standards for evaluating wildlife management are inappropriate.

The authors suggest the results of this case study are consistent with the idea that hatred is the reason people want to kill wolves. If so, and if science is not equipped to determine the "need" to hunt wolves, the authors argue that the question of whether to hunt wolves is not fundamentally a technical problem best solved by professionals, but instead a fundamentally normative issue.

Vucetich JA, Burnham D, Macdonald EA, Bruskotter JT, Marchini S, Zimmermann A, Macdonald DW. 2018. Just Conservation: What is it and Should we Pursue it? *Biological Conservation* 221: 23-33. DOI:10.1016/j.biocon.2018.02.022

Efforts to implement conservation measures are often met with stakeholders contending that particular actions are unfair and conflict with their basic interests and needs. In this context, Vucitech et al. suggest that the lens of social justice—which may be defined as the fair treatment of others judged according to the three principles of equality, need, and desert (noun form of deserve)—acts as a useful lens to characterize this dynamic. The authors contend that the values of social justice can conflict with the values of conservation, creating space for conflict among parties.

To elucidate this relationship, the authors suggest that socially just conservation requires adjustments by the conservation provider to: a) ensure that human interests be considered and b), if they are not, every effort should be made by all involved parties to mitigate the restriction to one's equality, need, and desert to the point of no longer being unjust.

Citing a case study addressing whether livestock owners should be restricted from killing predators that threaten to kill livestock, the authors offer a variety of scenarios as to whether the landowner should receive compensation to not kill the predator, who should bear the costs of the compensation, and

whether tribal members should be help to the same standards. The authors conclude by suggesting that the potential for conflict between conservation values and social justice values is dynamic, growing, and deepening as the abundance of humans and incursion into natural spaces increase.

Way J, Bruskotter J. 2012. Additional Considerations for gray wolf management after their removal from endangered species act protections. *Journal of Wildlife Management* 76(3):457-61.

Way and Bruskotter discuss wolf management, post-endangered species act delisting. They agree generally with others (Mech 2010) that the use of lethal management should be focused in areas of conflict and less in wilderness areas, especially near protected areas of habitat like national parks. They enumerate and expand upon several other points, which they suggest will make management plans more palatable to an increasingly diverse group of interested stakeholders, including: use of human dimensions research; employing preventative measures to protect livestock and pets; and, selective use of sport hunting.

Way and Bruskotter discuss ways in which wolf management controversy might be reduced, and whether wolf harvests reduce conflicts with livestock. They highlight the selective application of lethal techniques—targeting and structuring them to those contexts where wolf impacts and conflict are significant, and to situations where they can be expected to make a substantive difference.

In the authors' view, effective and publicly acceptable management scenarios would first employ proactive nonlethal methods, and encourage husbandry practices in an attempt to avoid conflicts in the first place. In these areas, managers would encourage non-depredating packs to live in multi-generational, social stable groups that teach their offspring to avoid humans and livestock. In areas where conflicts occur despite attempts at nonlethal coexistence, Way and Bruskotter advocate selective use of sport hunting to reduce wolf populations (as opposed to hunting as the de facto management tool). This might be accomplished by matching potential wolf hunters with affected producers/areas.

Wells SL, McNew LB, Tyers DB, van Manen FT, Thompson DJ. 2018. Grizzly Bear Depredation on Grazing Allotments in the Yellowstone Ecosystem. *Journal of Wildlife Management* 83(3):556-66. DOI:10.1002/jwmg.21618

Grizzly bear conflicts with humans, including livestock depredation on public land grazing allotments, have increased during the last several decades within the Greater Yellowstone Ecosystem (GYE). Minimizing conflicts and improving conservation efficacy requires information on the relationships between livestock depredations, allotment management, grizzly bear habitat conditions, and their interactions.

Wells et al. used generalized linear mixed models to evaluate spatio-temporal relationships between grizzly bear depredation of livestock and the characteristics of 316 U.S. Department of Agriculture Forest Service and National Park Service grazing allotments in the GYE, 1992–2014. Relationships between depredations and grizzly bear habitat conditions varied across spatial extents. Estimated number of depredation events increased by approximately 20% when cow-calf pairs increased by 100 pairs and grizzly bear density index increased by 1bear/196 km2. Further, grazing allotment size was positively related to the number of depredation events, whereas the presence of bull cattle or horses was associated with an approximately 50% reduction in depredations.

As the grizzly bear population continues to expand, the authors suggest that natural resource managers and livestock producers could focus efforts on allotments with a higher density of grizzly bears, fewer roads, and quality grizzly bear habitat, including higher vegetative productivity when developing cooperative management plans and preventative measures to reduce the likelihood of depredation.

Wielgus RB, Peebles KA. 2014. Effects of Wolf Mortality on Livestock Depredations. *PLoS ONE* 9(12). DOI: 10.1371/journal.pone.0113505

Gray wolves are currently being hunted in Idaho, Wyoming, and Montana in part to reduce livestock depredations. However, the long-term effectiveness of lethal wolf control to reduce livestock depredations is not known.

Wielgus and Peebles analyzed wolf depredation of livestock data in each state for each year from 1987 through 2012. Their results do not support the "remedial control" hypothesis of predator mortality on livestock depredations the following year. However, lethal control of wolves appears to be related to increased depredations in a larger area the following year.

While lethal control of individual depredating wolves may sometimes be necessary in the near-term, they recommend that nonlethal alternatives also be considered.

Wilson S, Bradley E, Neudecker G. 2017. Learning to Live with Wolves: Community-Based Conservation in the Blackfoot Valley of Montana. *Human-Wildlife Interactions* 11(3):245-57. DOI:10.26077/bf8e-6f56

Repeated incidents with livestock typically lead to wolf removals. In these cases, outcomes are unfortunate for both those losing livestock and for the wolves themselves. One way to break this cycle is to focus efforts on preventive measures that proactively address wolf–livestock conflict. To realize this concept, individuals expanded on an existing non-governmental organization called the Blackfoot Challenge to proactively address gray wolf livestock conflicts in the Blackfoot Valley of Montana.

Working across the public and private sectors with the Blackfoot Challenge, Wilson et al. employed a host of tools to reduce conflicts with wolves at a community scale that incorporated multiple wolf pack territories. Efforts to engage the community included one-on-one meetings, workshops, field tours, and regular group meetings as well as opportunities to participate in data collection and projects. Initial projects included permanent electric fencing of calving areas and livestock carcass removal to address the threat of grizzly bears and, later, wolves. The program observed an average of 2.2 cattle depredations a year out of approximately 17,000 cattle from 2006 to 2015, and an average of 2.2 wolves removed a year as the wolf population grew from 1 to 12 packs.

While the authors suggest that there is no one-size-fits-all approach to living with large carnivores like grizzly bears and wolves, they recommend four foundational principles for community-scale carnivore coexistence programs based on this case study: coordination of resources; efforts informed by science; incorporation of stakeholder values; and a decision-making process that rationally discusses the issues, make decisions, and implement actions in a participatory manner with stakeholders.

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Burchfield JA, Belsky JM. 2005. Natural Landscape Features, Human-Related Attractants, and Conflict Hotspots: A Spatial Analysis of Human-Grizzly Bear Conflicts. *Ursus* 16(1):117-29.

There is a long history of conflict in the western United States between humans and grizzly bears involving agricultural attractants. However, little is known about the spatial dimensions of this conflict and the relative importance of different attractants. Wilson et al. investigated the spatial relationships of rivers and creeks, livestock pastures, boneyards (livestock carcass dumpsites), beehives, and grizzly bear habitat in conjunction with reported human-grizzly bear conflicts from 1986 to 2001, on the Eastern Rocky Mountain Front, in Montana. They used density surface mapping to identify seasonal clusters of conflicts that functioned as conflict hotspots.

Hotspot locations accounted for 75% of all conflicts while encompassing only 8% of the study area, and 10 chronic hotspots accounted for 58% of all conflicts. Conflicts were most strongly associated with rivers and creeks, followed by sheep lambing areas and fall sheep pastures. They also were associated with cattle calving areas, spring cow-calf pastures, summer and fall cattle pastures, and boneyards.

The majority of conflicts occurred in a small portion of the study area, where concentrations of attractants overlapped bear habitat; hotspots that could be targeted by management and conservation efforts that focus on removing or protecting attractants using nonlethal techniques. Most deaths of sub-adult and adult grizzlies in the study region are caused by humans. A disproportionate number of these deaths occurred on private lands as a result of conflicts precipitated by attractants.

Patterns of depredation along the Eastern Rocky Mountain Front seem to be deeply rooted in the natural foraging behavior of grizzly bears. Knowing about potential problem sites provides the opportunity to proactively ameliorate more serious conflicts before they start. Wilson et al. suggest that behaviors of individual bears alone cannot adequately explain the observed patterns of conflict and that most conflicts were more likely the result of problematic contexts.

Wilson SM, Madel MJ, Mattson DJ, Graham JM, Merrill T. 2006. Landscape Conditions Predisposing Grizzly Bears to Conflicts on Private Agricultural Lands in the Western USA. *Biological Conservation* 130:47-59.

In this follow-on study, Wilson et al. modeled the relationship between different landscape conditions and the likelihood of human-grizzly bear conflicts. Their focus was on private agricultural ranch lands along Montana's Rocky Mountain. They used locations of livestock pastures, livestock carcass disposal areas (boneyards), beehives, and wetland–riparian vegetation to model the locations of 178 human-grizzly conflicts between 1986 and 2001.

The authors found that most conflicts were associated with concentrations of attractants located within productive bear habitat. They also found a very strong link between spatial and temporal collections of attractants and the likelihood of human-grizzly conflict.

Wilson et al. argue that grizzly bear management and conservation efforts on private agricultural lands should focus on locations where attractants are concentrated in high-quality bear habitat. Identifying, predicting, and responding to conflicts may be systematically accomplished by prioritizing efforts in

locations where the greatest number of attractants are found near to one another. The authors suggest nonlethal deterrent techniques such as electric fencing of beehives, calving areas, sheep bedding/lambing areas, and carcass removal. They note that this will require the active participation and collaboration of ranchers and landowners whose combined attractants are leading to chronic conflict situations.

Windh JL, Stam B, Scasta JD. 2019. Contemporary Livestock-Predator Themes Identified Through a Wyoming USA Rancher Survey. *Society for Range Management* 41(2):94-101. DOI:10.1016/j.rala.2018.11.007

Damage caused by wildlife is often the main driver of human-wildlife conflict and can exacerbate financial and emotional frustrations of ranchers. These frustrations can be misconstrued as anti-conservation sentiment. However, that could be an overly simplistic characterization and perhaps inaccurate description of ranchers' frustrations. Human and wildlife population trends, legislation at both the state and federal levels, and changing socioecological features relative to predator conservation are all dynamic factors that make it difficult for the policy and legislation to keep up with the rapidly evolving livestock-predator issues facing ranchers. Thus, a more in-depth understanding of the social dynamics relative to livestock-predator conflicts is needed.

Windh et al. surveyed 274 Wyoming ranchers using open-ended questions about contemporary livestock-predator issues. Four themes emerged related to mitigating losses, escalating impacts, predator management funding, and bureaucratic complexities. Underlying these themes was the tension between state and federal control including about growing predator populations.

The authors suggest that if Wyoming producers felt that groups working toward the conservation of certain species also had the ranchers' interests in mind, there could be less resistance to peaceful conflict resolution. They argue that a complete systems analysis, including environmental, institutional, and socioeconomic factors, is necessary for the successful implementation of a conservation program.

Wolf C, Ripple W. 2018. Rewilding the World's Large Carnivores. *Royal Society Open Science* 5:172235. DOI:10.1098/rsos.172235

Earth's terrestrial large carnivores form a highly endangered group of species with unique conservation challenges. The majority of these species have experienced major geographical range contractions, which puts many of them at high risk of extinction or of becoming ecologically ineffective. As a result of these range contractions and the associated loss of intact predator guilds, the ecological effects of these species are now far less widespread and common, with inevitable consequences for ecosystem function. Rewilding, which includes reintroducing species into portions of their former ranges, is an important carnivore conservation tool and means for restoring top-down ecological regulation.

Wolf and Ripple conducted a global analysis of potential reintroduction areas, identifying a total of 130 protected areas that may be most suitable for carnivore reintroduction. In addition, they identified contiguous low human footprint regions within the former ranges of 25 large carnivore species analyzed, identifying an additional 150 areas which could be the focus of conservation efforts to create conditions conducive to reintroductions.

As the first spatially explicit global assessment of future large carnivore rewilding possibilities, this study recognizes the need for inclusion of additional assessments of identified target areas' prey dynamics, landscape connectivity, and social dimensions prior to reintroduction. Results from this study indicate the global-scale potential for carnivore rewilding and reintroduction as a means to conserve large carnivore species, while enhancing their ecological and social effects throughout landscapes.

Young JK, Hammill E, Breck SW. Interactions with Humans Shape Coyote Responses to Hazing. *Scientific Reports.* 9:20046 DOI:10.1038/s41598-019-56524-6

Hazing wildlife (i.e., scaring wildlife) is often promoted as a non-lethal means for reducing human-wildlife conflict, with the aim of changing an animal's behavior or to cause it to move away. Although hazing is frequently promoted in urban communities coexisting with carnivores, Young, Hammill and Breck maintain there is limited scientific evidence to support its efficacy.

The authors tested the efficacy of hazing by simulating human-coyote interactions with a captive population of coyotes (*Canis latrans*) in Utah. Coyotes were first exposed to five days of a human-treatment period in which an adult, a child, or an adult with a dog simulated typical human interactions with coyotes in urban areas. This was followed by five days of hazing treatment. The authors found that past experiences with adults—i.e., whether they had been hand fed by adults or not—significantly affected the coyote's reaction to hazing. They also noted that past experiences with children did not impact the number of hazing events.

Young Hammill and Breck conclude that hazing could be a useful management tool, as coyotes in the study learned to avoid behaviors warranting hazing. They caution that prior experience and whether the interaction is with an adult or a child can alter the outcomes of hazing and should be considered in determining the efficacy of hazing programs in urban areas.

Young JK, Ma Z, Laudati A, Berger J. 2015. Human-Carnivore Interactions: Lessons Learned from Communities in the American West. *Human Dimensions of Wildlife* 00:1-18. DOI:10.1080/10871209.2015.1016388

Most strategies for addressing human-carnivore conflicts in rural areas have focused on mitigating economic loss. Such strategies, however, often fail to adequately account for changing and varied perceptions of those who directly interact with carnivores on a regular basis (Montag 2003). There remains a need to better understand how non-ecological factors, especially those beyond economics, shape human-carnivore conflicts and are linked to human-carnivore coexistence (Dickman et al. 2011, Inskip and Zimmerman 2009, Jacobson et al. 2012, Kellert et al. 1996).

Focusing on four rural communities in Idaho, Montana, and Washington, Young et al. conducted focus groups and interviews to assess the complexities of human-carnivore interactions and to determine factors influencing individual willingness to coexist with carnivores.

They found that: i) participants spoke more about socioeconomic and political factors than ecological ones; ii) desired actions that were articulated appeared to correlate with historical context; and iii), there seemed to be a link between a community's willingness to coexist and state management policies.

Young et al. suggest a need to better understand how different stakeholders interpret scientific information, what strategies can facilitate effective communication among stakeholders, and what makes stakeholders feel treated justly when human-carnivore conflicts occur.

Young J, Miller E, Essex A. 2015. Evaluating Fladry Designs to Improve Utility as a Nonlethal Management Tool to Reduce Livestock Depredation. *Wildlife Society Bulletin* 39(2). DOI:10.1002/wsb.532

Nonlethal deterrents against carnivores are important components to protecting livestock and conserving carnivore populations. However, the performance of the visual deterrent called fladry, a historical tool used to defend livestock from carnivores, is often hindered by design flaws that eventually reduce its effectiveness.

Young et al. assessed fladry designs in order to identify one that reduces coiling (i.e., wrapping of individual flags tight to the rope from which they hang) and maintains free movement of the deterrent in the wind. They created six new designs, replicated designs using two materials (nylon and marine vinyl), and compared them with the design most commonly used today—where flags are sewn directly onto the line along which they are strung.

The authors found that fladry made of marine vinyl and attached via two of their six designs showed the least amount of coiling, were relatively easy to construct, and did not result in significant additional costs. The 2 designs were shower curtain, where the flags are attached via circular links, and knotted, where a knot is tied in the flag below its point of attachment. They suggest users of nylon fladry modify it to one of these designs, and they advise new users to consider a heavier (e.g., marine vinyl) material.

Young J, Steuber J, Few A, Baca A, Strong Z. 2018. When Strange Bedfellows Go All in: A Template for Implementing Non-Lethal Strategies Aimed at Reducing Carnivore Predation of Livestock. *Animal Conservation.* DOI:10.1111/acv.12453

Increased abundance and distribution of grizzly bears and wolves in the Rocky Mountains has led to increased predation of livestock in areas where livestock producers have not needed to implement conflict prevention methods in recent history. Where possible, conservation practitioners favor increased use of nonlethal tools to replace lethal methods aimed at preventing depredation of livestock. Nonlethal tools that reduce livestock depredation could facilitate coexistence; however, scientists note a distinct lack of experimental studies that adequately evaluate the efficacy of nonlethal tools.

Developing a case study of the efficacy of nonlethal tools to reduce livestock depredations, a joint USDA-WS and NRDC project recruited landowners to implement fladry and turbo fladry to protect their herds from January to April (calving season). A monitoring regime of four trail cameras at each corner of the fladry fence was implemented at each project. Wolves were detected outside of the pastures protected by fladry via camera traps at two projects in Montana and one project in Oregon. Wolves were also detected by a livestock producer in person at the same project in Oregon and via back-tracking in snow at one livestock operation in Idaho. One depredation event occurred with fladry in place, a landowner in Oregon suffered the loss of two calves the day after fladry was removed, and depredations occurred in fields adjacent to fladry installation in Montana.

While the authors do not make scientific conclusions on the effectiveness of fladry and turbo fladry, they offer three recommendations on running successful fladry programs within communities. Working collaboratively across several types of agencies and organizations allowed doors to open that may not have opened for any one particular group; the collaboration allowed several sources of financial and personnel resources to be available to livestock producers; and monitoring provided an evidence-based approach to encourage participation by more livestock producers and convince producers of fladry's value.

Zajac RM, Bruskotter JT, Wilson RS, Prange S. 2012. Learning to Live with Black Bears: A Psychological Model of Acceptance. *Journal of Wildlife Management* 76(7):1331-40. DOI:10.1002/jwmg.398

The recovery or large carnivores in human-dominated landscapes creates a need to understand how people will respond to the presence of these animals. Zajac et al. tested a psychological model of acceptance to determine what variables most influence people's acceptance for black bears in an area in Ohio with an emerging black bear population.

The authors hypothesized that people's perceptions of risk and benefit related to bears would mediate the effect of trust (in wildlife management agencies) and personal control (over interactions with and management of wildlife) on acceptance for black bears.

They found that interventions raising an individual's social trust in the managing agency, or personal control can indirectly raise stakeholders' acceptance by reducing risk perception and increasing perception of benefits from carnivores.

The authors suggest that, as large carnivore population expand and interactions with humans increase, these results could aid managers in designing outreach materials and communications aimed at promoting acceptance for large carnivores.

Zarco-Gonzalez, M., Monroy-Vilchis, O., Rodriguez-Soto, C., Urios, V. 2012. Spatial Factors and Management Associated with Livestock Predations by *Puma concolor* in Central Mexico. *Human Ecology* 40(4):631-38. DOI:10.1007/s10745-012-9505-4

There have been numerous studies on the economic loss of predation on livestock, but few studies have been done that assess the relationships between livestock management practices and predations, and even fewer suggesting predation sites were associated with topographic feature. Zarco-Gonzalez et al. evaluated relationships between livestock predation risk and local topographical factors, and assessed livestock management practices in this region in central Mexico.

A previous study in the region indicated that livestock contributed only 8.2% of the relative biomass of puma prey, mainly remnants of cows and goats. This supports the conclusion that felids in this region kill fewer domestic animals than livestock holders believe. In all confirmed cases, puma was considered the responsible predator, which was supported by evidence found in more than half of the attacks. On the other hand, livestock holders identified this species in all sightings.

In addition, although most the domestic prey were adults, Zarco-Gonzalez et al. noted that livestock holders do not keep records of livestock births and commented that occasionally offspring disappear. It

is likely that some of these losses are due to predations and that predation of young may occur more frequently than perceived. Free-range grazing also appeared to be more susceptible to predation. In the study zone most animals graze in large groups, often far from human settlement, which implies greater risk to pumas as group size is positively correlated with predation with groups less than 20 individuals most at risk. The lack of night shelter increases the livestock vulnerability in relation to the nocturnal habits of puma. Although the overall percentage of livestock loss by predation is relatively low, because these are marginalized communities the losses are considerable, and account for about 17% of the total value of livestock present in the sites of attacks.

The authors found a high percentage of losses were concentrated in a few sites, which are known as hotspots and a site effect. This study is one of the first to evaluate and to confirm this site effect through the influence of physiographic variables at the sites of attack. Zarco-Gonzalez et al. conclude that the importance of characterizing attack sites using predictive models allows focusing prevention efforts and mitigation measures in high-risk areas.

Zeller KA, Wattles DW, Conlee L, DeStefano S. 2019. Black Bears Alter Movements in Response to Anthropogenic Features with Time of Day and Season. *Movement Ecology* 7:19. DOI:10.1186/s40462-019-0166-4

With the growth and expansion of human development, large mammals will increasingly encounter humans, elevating the likelihood of human-wildlife conflicts. Understanding the behavior and movement of large mammals, particularly around human development, is important to crafting effective conservation and management plans for these species.

Zeller et al. used GPS collar data from American black bears to determine how seasonal food resources and human development affected bear movement patterns and resources across Massachusetts. They found that though bears moved and avoided human development more during crepuscular and daylight hours than at night, they preferentially moved through human-dominated areas at night. This indicated that bears were mitigating the risk of human development by altering their behavior to exploit these areas when human activity was low; a shift that was most prominent in the spring and fall.

They also found seasonal and diel differences among individual bears in resource selection during movement. Accounting for these individual, seasonal, and diet differences when assessing movement for large mammals is especially important if predictive surfaces are to be used in identifying areas for conservation and management. The authors conclude that black bears in Massachusetts are operating in a landscape of fear and are altering their movement patterns to use developed areas when human activity is low.