Landowner collaborative strategies for nonlethal predator control

Lead: Heart of the Rockies Initiative

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1. Project Summary

Protecting livestock from predators is a complex endeavor, with each case requiring an assessment of dynamic ecological, economic, and social influences. Successful reduction of conflicts with predators requires an analysis of the efficacy and economic efficiency of various techniques. These analyses are only productive when integrated with opportunities to incentivize local landowners and community members to learn, formulate solutions through planning, and continue to adapt when needed. The goal of the project is to reduce the financial and social burden of expanding predator populations through innovation and evaluation of techniques that reduce agricultural conflict with predators, leading to more resilient ranches and connected landscapes.

This project focused on co-producing, evaluating, implementing, and educating producers about three primary nonlethal conflict prevention techniques in an effort to help incorporate them into an NRCS framework. We coordinated across seven western states with 14 independent producers and nine landowner collaboratives representing more than 600 producers in what is likely the most comprehensive effort to understand and enhance the use of these tools. Over the course of the project, the team held annual Stewards of the Working Wild Workshops to exchange knowledge and accelerate innovation of producer-led implementation of nonlethal techniques, developed a technical reference guide to share research insights (see appendix), a technical paper to inform implementation of Conservation Practice(s) (see appendix), and a producer "toolkit" for conflict reduction, while hosting five webinars. Notably, this project has resulted in accelerated, expanded, and sustained funding for these techniques through adoption for cost-sharing through NRCS EQIP, and laid the groundwork for two RCPP projects that have leveraged $22 million in support for these techniques.

2. Project Goal and Objectives

The goal of the project was to reduce the financial and social burden of expanding predator populations on producers through innovation and evaluation of techniques that reduce agricultural conflict with predators, leading to more resilient ranches and connected landscapes. This goal was pursued through the following objectives: 1. Coordinating with independent livestock producers, local landowner groups, and collaborative stakeholder groups in the implementation and evaluation of nonlethal predator control techniques. 2. Facilitating peer-to-peer stakeholder knowledge exchange to accelerate innovation of nonlethal predator control techniques and develop guidelines for successful collaborative conflict reduction programs. 3. Synthesizing and making project results available to NRCS for consideration of new or modified Conservation Practice Standards (CPS) for the benefit of grazing lands, wildlife and other resources. 4. Integrating the collective experience and knowledge gained through the project by developing and disseminating a comprehensive "Livestock Producer Toolkit For Conflict Reduction" as user-friendly guides for effective implementation approaches to nonlethal techniques.

3. Project Background

Because of economic marginality and ecological insecurity of working ranchlands throughout the West, pressure to sell ranches for land conversion can be strong and land tenure security low (Sayre et al. 2013). With these conditions as a backdrop as recovering predator populations expand and occupy new working lands, producers are challenged to adapt often centuries-old techniques and employ new tools on an effective and swift time frame to prevent livestock losses. Although lethal control can be effective as a short-term solution, wildlife will often reestablish and cause conflicts again in the same areas; this pattern has been observed with wolves that reestablish a new pack within two years of full pack removal (Bradley et al. 2015). Thus, for long-term viability of livestock operations and carnivores sharing the same landscape, exploration of nonlethal conflict prevention techniques is warranted.

One barrier to livestock producers and wildlife managers employing conflict prevention is that often the most promising and innovative tools are unknown to producers and managers alike because they are the least researched and communicated. Additionally, producers who try new innovative tools are often geographically separated from other producers confronted with the same challenges, limiting a key mechanism of information transfer. Producers are more likely to employ nonlethal techniques they learn from trusted sources, such as neighbors and local, state, or federal employees (e.g., Young et al. 2018). Working across jurisdictions with landowners on different ecological landscapes and with agencies in different states has also been prohibitive for widespread development, synthesis and evaluation of these tools.

Much research has been done to support livestock producers in finding innovative and creative ways of minimizing predation impact while simultaneously reducing impacts to large carnivores and maintaining their critical ecological role on the landscape. However, significant hurdles remain on working landscapes. Two primary hurdles include: 1) increased knowledge of and peer-to-peer dissemination of effective implementation approaches that can increase agricultural productivity while providing habitat for large carnivores, and 2) the propagation of new and existing techniques on working landscapes driven by place-based, landowner-led collaboratives. This project focused on tackling both of these issues by providing a multi-scale examination of the efficacy of new innovations and expanded applications of trusted conflict prevention techniques implemented by producers with the support of landowner collaboratives and NGO stakeholders.

4. Project Methods

Objective 1. Implementation and Evaluation: Project partners coordinated across seven western states on the implementation and evaluation of conflict prevention techniques. Working with independent producers and producer groups, along with multi-stakeholder collaboratives, the project team supported novel and ongoing applications of range riding, carcass management, and fencing. The research team worked closely with Technical Advisory Committees (TACs) to co-produce research questions that were relevant to the needs/interests of participating livestock producers. The TACs included representatives of APHIS Wildlife Services, research universities including Utah, Colorado, and Montana State Universities, leaders of place-based collaborative groups such as Northeast Washington Wolf Cattle Collaborative, NGOs including Defenders of Wildlife, conflict reduction specialists, and landowners and livestock producers. The research team compiled a literature review on effectiveness of the three techniques to inform the "Scientific Technical Reference Guide' (see appendix), which succinctly describes the scientific understanding on effectiveness of the three techniques.

Objective 2. Facilitate peer-to-peer stakeholder knowledge exchange to accelerate innovation: To identify best practices for organizing and maintaining collaborative conflict prevention programs, our team conducted a literature review and interviewed stakeholders and livestock producers representing collaboratives to understand what factors lead to the formation and potential success of these groups. Informed by 20 semi-structured interviews with relevant stakeholders analyzed using thematic content analysis, we identified best-practices for forming place-based collaborative groups integral for supporting successful conflict reduction at landscape scales. To best facilitate shared learning, annual workshop agendas were co-produced with the CoW-CIG team and producer partners.

Objective 3. Enhance conservation planning and program implementation: Based on the evaluation of the effectiveness and costs of conflict prevention techniques (Objective 1) and best management practices developed through peer-to-peer stakeholder learning at annual workshops (Objective 2), we provided project results to NRCS to aid them in examining existing Conservation Practice Standards and determining if modifications were needed. The technical paper was developed in knowledge of NRCS processes with the CoW-CIG team, state conservationists, and the NRCS Western Tech Center, so that if accepted as a National Tech Note by NRCS, it would match necessary bounds and requirements.

Objective 4. Integrate collective experience and knowledge of partners: The "Producer Toolkit for Conflict Reduction" will facilitate producer adoption of the most effective implementation approaches to conflict prevention techniques based on ranch-specific goals, capacities, and resource conditions. The contents of the Toolkit were co-produced with livestock producer partners and CoW-CIG researchers through Technical Advisory Committees that met regularly to provide input.

5. Project Results

Objective 1**.** Implementation and Evaluation: Over the three years of the grant, the CoW-CIG team worked with 14 individual producers and 9 place-based groups representing 15 million acres to implement and evaluate conflict prevention techniques. The research team responsible for the evaluation component of this work engaged producers within innovative and representational processes to co-produce research questions and study design at each step of the research process. Trust-building, co-producing research questions, and running field trials across a wide geographical scope takes significant time and resources. Research on the effectiveness of these techniques will continue after the conclusion of this grant, and will work to contribute critical insights for effective implementation in the future.

Advised by Dr. Julie Young of Utah State University, Rae Nickerson, the PhD candidate leading the range riding research effort, is working with 14 ranches across five states. To examine the influence of varied rider activity and intensity on direct and indirect livestock losses, the research team has been collecting several data streams including range rider daily logs, environmental data such as forage quality, predator data from rider observations, cameras traps, and data sharing agreements with state and federal wildlife agencies, and cattle behavioral and chemical data to document behavioral and chemical responses to predator-induced stress. Additionally, Rae collected extensive interviews with livestock producers and range riders as part of a transdisciplinary approach to applied research. Together, this data will inform the most comprehensive study on the effectiveness and application of range riding to date. Rae is currently in field season three and will analyze and write up her findings with regular feedback from the broader co-production team by spring 2026.

Advised by Dr. Stewart Breck of the USDA National Wildlife Research Center and Colorado State University, Matthew Hyde, the PhD candidate leading the carcass management and fencing evaluation effort, has established data sharing agreements with Oregon Department of Fish and Wildlife and Montana Fish, Wildlife and Parks to glean spatial information on wolves and grizzly bears indicating locations and use of areas with and without bone piles. Matt worked with the Fencing TAC to create a qualitative survey to distribute to producer partners and other producers across the West. This survey addresses producer adoption and perceived efficacy of the practice which will then be compared to geographic location and previously researched fence designs. Documenting this process, Hyde and co-authors published a research paper titled "Multidisciplinary engagement for fencing research informs efficacy and rancher-to-researcher knowledge exchange," providing recommendations on the process of co-producing research with livestock producers. Mr. Hyde is currently in field season three and will in co-production approach, analyze and write up the findings in spring 2025.

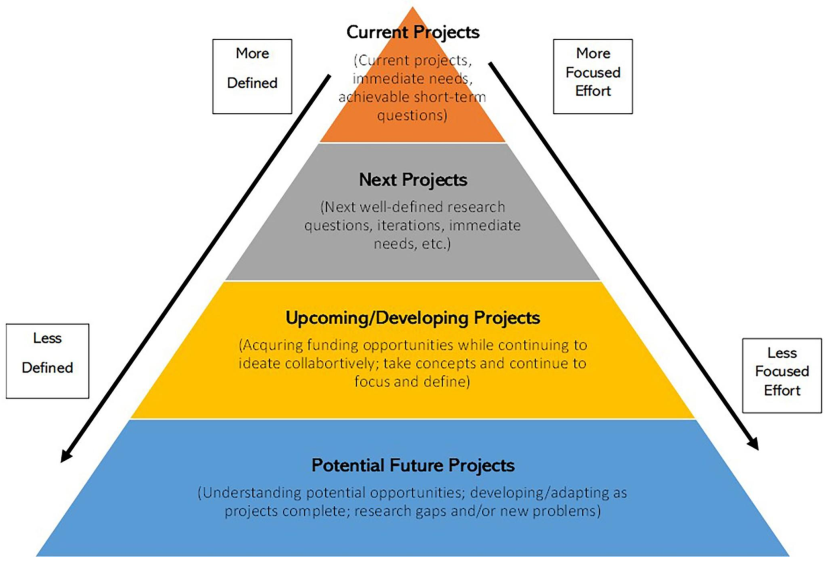

Figure 1: Research goals or questions are set by the co-production group according to this diagram, where well defined, short-term questions are addressed more immediately, but at the same time the team develop new project ideas to address in the medium-term, and developing projects based on participant input that may fall outside of current funding or time limitations. Credit: Dr. Jared Beaver Montana State University Extension

Synthesizing experience from ongoing research on range riding, carcass management, and fencing as well as providing critical support to partners seeking scientific literature on use cases and effectiveness of these techniques, the CoW-CIG team authored the "Scientific Technical Reference Guide" (see appendix). This guide offers a comprehensive literature review for each practice, as well as foundational information important to consider for the most effective application. This document is included within the appendices of this report.

Objective 2. Facilitate peer-to-peer stakeholder knowledge exchange to accelerate innovation: This project accelerated peer-to-peer knowledge exchange through three pathways: 1. Convenings; 2. Webinars; and 3. A road map to forming place-based collaboratives.

1. Convenings: Over three years, project partners convened nine meetings/workshops to support knowledge exchange amongst communities around the West, focus local efforts to reduce conflicts, and build trust amongst diverse stakeholders necessary to support a successful community of practice around conflict reduction. These convenings drew 700 participants, and when individuals were queried, all indicated an overall "Excellent" rating for the meetings. One individual specifically stated that they "Will continue to develop relations with folks and work on sharing resources and knowledge, especially for on-the-ground tool implementation." In addition, three range rider specific workshops will be held this coming fall and next spring in Oregon, Arizona, and Washington. Project collaborators were surveyed to best cater workshops to producer/rider interest and need. We expect over 200 participants total including producers, riders, state and federal wildlife, land grant, and agriculture agency staff, researchers and Extension, NGO's and place-based collaboratives, local and state representatives, and other collaborators.

2. Webinars: The team held five webinars, attracting over 1,000 viewers. Webinars on Range Riding, Fencing/Fladry, and Carcass Management highlighted producer experience and knowledge on best practices for implementation and highlighted the research effort furthered by

this project. A webinar hosted in conjunction with NRCS provided an overview of the CoW-CIG grant and highlighted practice and scenario development. Lastly, the Producer Toolkit webinar provided a comprehensive overview of risk assessment, context specific implementation, and adaptive management important to the successful implementation of techniques.

3. Road map to place-based collaboration: Place-based collaborative groups provide a way to coordinate community-scale action to address wildlife-livestock conflicts, and processes to lift landowner and livestock producer needs, while finding areas of agreement and shared purpose to meet a variety of resource challenges. These groups, many of which are landowner-led, may include all or part of a particular community and offer a way to meaningfully engage state and federal wildlife agencies, non-profit organizations and other stakeholder groups within a community-level decision-making process. Informed by interviews and co-produced with existing place-based groups, the CoW-CIG team developed the "Road-Map to Place Based Collaboration for Conflict Reduction", a hands-on guide for developing landowner-led, place-based collaborative groups with a focus on reducing wildlife-livestock conflicts. While the regulatory context, stakeholders, wildlife, and landscape will vary, this 10-step guide outlines a process and provides examples to aid landowners and practitioners in developing community-led solutions to address wildlife-livestock conflicts. Four case studies provide on-the-ground examples of how place-based collaborative groups have formed and organized to address conflicts and support landowner and wildlife needs.

Objective 3**.** Enhance conservation planning and program implementation: Through focused work with livestock producers and landowners, and NRCS leadership, this grant effort compiled information that when adopted by NRCS, supported development of cost-sharing opportunities for range riding, carcass management, and fencing through existing and novel NRCS practices. Specifically, NRCS developed a new payment scenario for turbo-fladry within an existing practice, and an interim practice standard for carcass management. Building off availability of predation risk management practices, two Regional Conservation Partnership Program (RCPP) grants were awarded to a consortium led by Western Landowners Alliance (WLA) and Heart of the Rockies Initiative (HRI). Approximately $16.5 million will support the "Stewarding the Working Wild" project in Montana, Oregon, and Colorado, led by HRI, in close partnership with WLA. The project will use a holistic approach to incentivize producers to implement solutions that benefit land, livestock, and wildlife. Over $6.5 million will go to the "Grazing Management and Non-Lethal Predator Risk Mitigation" project in New Mexico and Arizona led by WLA. Within the 5-state project area of these RCPP's, NRCS is piloting a range riding scenario delivered through an existing practice. By providing technical assistance and cost-share finance for multi-benefit techniques like range riders, carcass composting facilities, fencing and related technologies, the partners expect improvements in range and herd health, reduction in conflict between livestock and carnivores, and improved permeability of wildlife habitat.

As part of the process for supporting implementation of practices, HRI and WLA, along with other CoW-CIG team members, authored a technical paper titled "Reducing Risk on the Range: Non-Lethal Practices for Managing Carnivore-Livestock Conflicts" (see appendix). Aligned with guidance from NRCS resource specialists at the state, regional, and Headquarters levels, this document provides information on evaluating risk of carnivore predation over space and at different times of day and year, offers background information on the form and functions of range riding, carcass management, and electric fencing/fladry, and outlines principles to guide practice implementation and adaptive management. This document was developed to be easily converted into a National Tech Note if NRCS chooses to do so.

The information within this document is conveyed through two frameworks; the Risk Assessment Framework that works to understand when and where there may be risk of depredation within a specific landscape; and the principles of predation risk management that considers implementation and adaptive use of techniques over time. A diverse group of stakeholders contributed to the development of the six principles with the goal of minimizing livestock-wildlife conflict and its impacts, while supporting working landscapes that provide both economic security and wildlife habitat. The six principles are: (1) Know your context, (2) Identify your goals, (3) Design context specific implementation, (4) Collaborate and communicate for success, (5) Assess current and emerging strategies and technologies, and (6) Adapt activities based on changing opportunities.

These principles are intended to serve as a guide for landowners, conservation planners, and other partners in designing and deploying site-specific conservation activities to reduce conflicts while managing landscapes for multiple production and conservation values. This is the overarching framework that is used throughout the document to support the identification, implementation, and adaptive use of non-lethal risk management activities, including range riding, carcass management, and different fencing/fladry scenarios.

Objective 4**.** Integrate collective experience and knowledge of partners: The primary pathway for integrating the collective experience and knowledge of partners was through the producer toolkit for conflict reduction. Guided by livestock producers and other dedicated people working on a daily basis to reduce, manage and mitigate predation risk on working wild landscapes, the toolkit highlights decades of experience compiled into three documents and is a compilation of direct experience and knowledge of risk assessment, range riding, carcass management, and various types of electric fencing.

Figure 2: Range riding schematic

Developed through Technical Advisory Committees, these documents were co-produced amongst livestock producers, researchers, and non-profit and state agency representatives. Each document provides a comprehensive overview of range riding, carcass management, and fencing, and conveys context specific application through the risk assessment framework as well as the six principles of predation risk management mentioned above. Of note, the Range Riding Toolkit provides a concise definition of the practice, (see Figure 2), as well as best practices for implementation– two important contributions that have not been well described in other producer-facing documents prior. The Carcass Management toolkit provides a novel contribution in categorizing and describing the four phases of carcass management: 1. Finding and securing a carcass; 2. Temporary or permanent ranch facility; 3. Transportation; and 4. Community carcass management facility. The Fencing Toolkit offers an overview of four widely used types of fence – turbo-fladry, electric night pens, 4 and 5-wire fences, and electric drive over "unwelcome mats" – as well as information to guide their context specific implementation. The documents also include case studies highlighting on-the ground application of each practice in different contexts throughout the West. In order to disseminate information and highlight the producers whose knowledge led the way for forming this document, the project team hosted a webinar attended by over 200 individuals from all seven states within the project area.

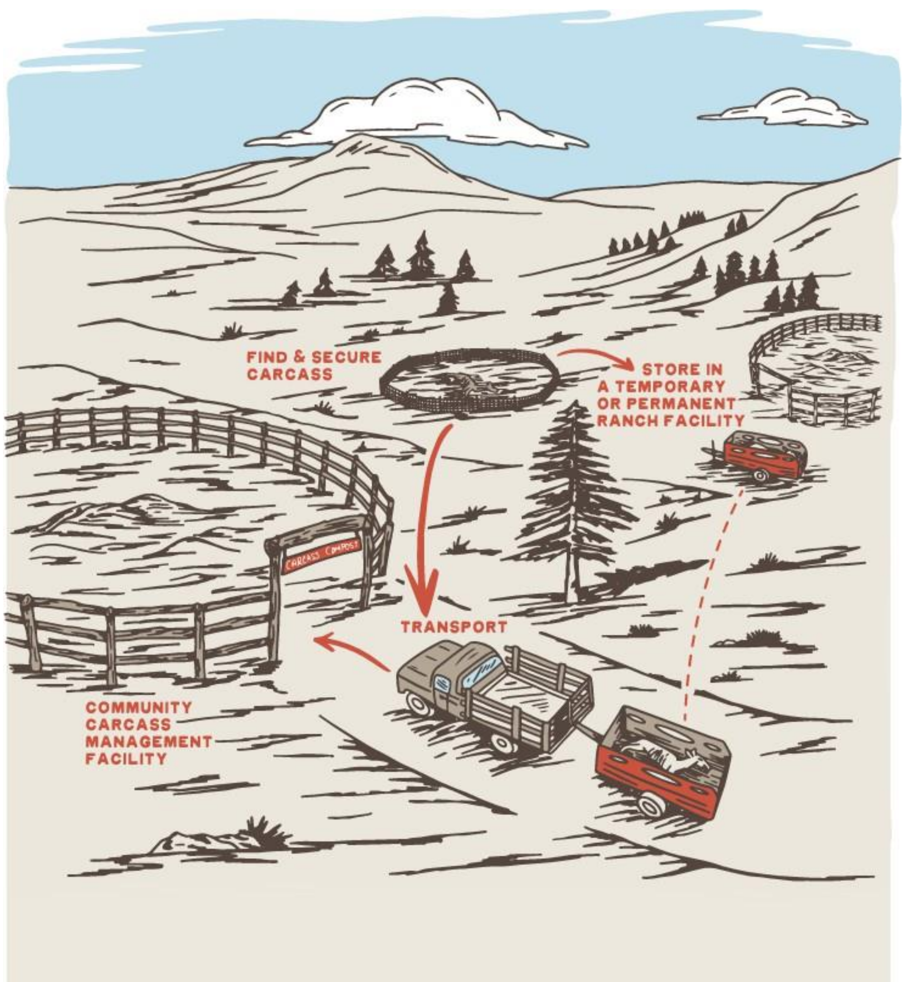

Figure 3: Carcass management schematic

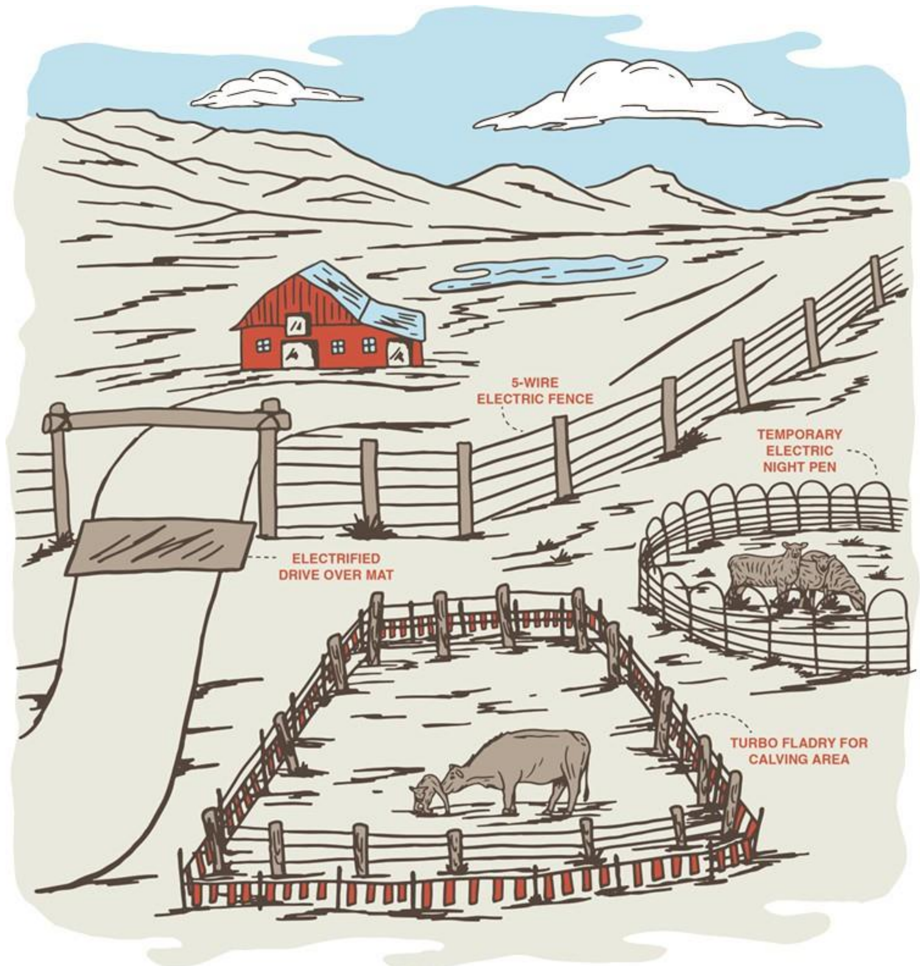

Figure 4: Electric fencing schematic

6. Project Outputs

Peer Reviewed Publications

- Hyde, M., Breck, S. W., Few, A., Beaver, J., Schrecengost, J., Stone, J., Krebs, C., Talmo, R., Eneas, K., Nickerson, R., Kunkel, K. E., & Young, J. K. (2022). Multidisciplinary engagement for fencing research informs efficacy and rancher-to-researcher knowledge exchange. Frontiers in Conservation Science, 3.https://www.frontiersin.org/journals/conservation-science/articles/10.3389/fcosc.2022.938054

Earned Media

- Federal Grants will help ranchers develop non lethal wolf deterrents
- On the Fence: New Research Taps Rancher Expertise on Living With Carnivores
- Montana State University Extension launches podcast on wolf reintroduction, ranching
- A new wolf-focused podcast wants to create a mutual understanding of wildlife and working land issues
- Wyoming rancher details experience with wolves
- Save Ranching and Wildlife - Invest in Relationships

- Oregon ranchers test nonlethal wolf deterrents
- Political beasts
- What can Americans Agree on? Wolves
- Colorado set to receive $2 million in federal conservation funds to help mitigate the conflict
- Collaboration gets you farther than insults
- USDA, USFWS, State Partners Find Non-Lethal Answers to Grizzly Bear Interactions on Montana Ranches

Stories
- Lava Lake Institute's Wood River Wolf Project
- Surprising benefits of range riding at Alderspring Ranch
- Acting odd on the range to change carnivore behavior
- Composting a Recipe for Conflict Reduction
- The BalancingAct: PublicWildlife on Private Lands
- Wolf Monitoring that Works For Ranchers
- Seeing Red: Montana Ranchers and The Line Between Conflict and Coexistence
- The Balancing Act: Public Wildlife on Private Lands
- Research Roundup: Is An Ounce of Prevention Worth a Pound of Cure?
- Western Landowners Welcome Historic USDA Working Lands Investment
- An official Grizzly In the Big Hole
- 22 million to help ranchers steward habitat and reduce conflicts with large carnivores

Podcast episodes
- Working Wild U Season 1 - Wolves in the West
- Working Wild U - Episode 11 - Old World Tools to New World Technology
- Place-Based Collaboratives and Conflict Reduction with Matt Collins

Webinars
- Range Riding
- Fencing/Fladry
- Carcass Management
- Conflict on Working Lands Classic CIG Grant Review Webinar
- Producer toolkit webinar

Products
- The Producer Toolkit For Conflict Reduction including the: Range Riding, Carcass Management, and Electric Fencing producer toolkits,
- The Roadmap to Place-Based Collaboration for Conflict Reduction
- The Scientific Technical Reference Guide (Attached)

Technical papers

- Collins, M., Owens, B., Breck, S., Burnett, G., Owens, N., Beaver, J., Hyde, M., Nickerson, R., Young, J., Williams, J., Kunkel, K., Gage, E., Justus, G. 2024. Reducing Risk on the Range: Non-Lethal Practices for Managing Carnivore-Livestock Conflicts. (See appendices)

Websites
- westernlandowners.org/working-wild-challenge, which hosts information, resources, and updates on programming for livestock producers and the public about conflict reduction with

wildlife, received an average of 850 unique hits per year from 2021-2024.

Conference attendance

- Collins, M. and Breck, S.W. 2024. Reducing Risk on the Range: Co-Production and Cost Sharing for Managing Carnivore-Livestock Conflicts. Colorado Parks and Wildlife Annual Meeting.
- Burnett, G.W. and Owens, B. 2022. Poster presentation at the CIG Showcase at the Soil and Water Conservation Society Annual Conference.
- Burnett, G.W. 2023. Oval presentation at the CIG Showcase at the Soil and Water Conservation Society Annual Conference.
- Breck, S.W. 2023. Keynote Address at Forum for Human-Carnivore Coexistence in Rome Italy. Sponsored by the US State Department Embassy in Italy.
- Breck, S.W. 2023. Coproducing knowledge to aid human-carnivore conflict mitigation. Pathways
- Breck, S.W. 2023. USDA WS agency updates on Nonlethal Initiative Research (NLI meetings, Predator project Current Bite Size Update, WS NLI Meeting)
- Collins, M**.** 2022 Place-Based Collaboratives for Minimizing Human-Carnivore Conflict: Collective Factors Driving Success Throughout the American West. International Wolf Symposium.
- Collins, M**.** 2023 Place-Based Collaboratives for Minimizing Human-Carnivore Conflict: Collective Factors Driving Success Throughout the American West. The Wildlife Society Colorado Chapter Annual Meeting.
- Owens, N. Carnivore Conflict Prevention Workshop. Interagency Grizzly Bear Committee Executive Committee Meeting. December 2023.
- Owens, N. Delivering federal investments in grizzly bear conflict prevention in MT through partnerships. Interagency Grizzly Bear Committee Information, Education, and Outreach Summit. January 2024.
- Owens, N. Carnivore Conflict Reduction Montana Updates. Interagency Grizzly Bear Committee Executive Committee Meeting. June 2024.

Trainings and outreach events

- Beyond Conflict: October 17th, 2021 - 65 participants
- Reducing Conflict with North Park Wolves: June 20th, 2022 - 35 participants
- Conflict Reduction Consortium Annual Meeting: October 11th-12th 2022 - 30 participants
- Conflict Prevention/Coordination Meeting: June 14th-15th, 2023 - 105 participants
- Range Management and Range Riding in NM/AZ: July 8th, 2023 - 66 participants
- Klamath, OR Conflict Reduction Workshop: August 22nd-24th - 80 participants
- Preparing for Wolves (Rifle, CO):November 7th, 2023 - 180 participants.
- Resources for Conflict Reduction (Pinedale, Wy): November 3rd, 2023 - 50 participants
- Conflict on Working Lands Conservation Innovation Grant Annual Meeting: February 27th-28th, 2024 - 55 participants

Newsletters

- 13 newsletters were sent to an average list of 3,500 people, with an average open rate of 44%. The industry standard open rate is only 28.5%, according to Google.

Email updates

- Monthly email updates on the range riding research have been sent to anyone who signs up. We send them in all months in which fieldwork occurs and less than monthly during the ‘off’ season. Subscribers get ~8-9 annual emails about the research. The list has ~115 recipients.

7. Project Impacts

The CoW-CIG team set out with the goal to reduce the financial and social burden of expanding predator populations to livestock producers through innovation and evaluation of practices that address conflict with predators, leading to more resilient ranches and connected landscapes. The project team has met this goal through the development of a community of practice in conflict reduction, through numerous co-produced products, and by furthering research around conflict prevention practices. Importantly, these combined efforts have contributed to novel cost sharing opportunities that will support livestock producers, reduce conflicts, and increase landscape permeability for predators.

Community of practice: This grant developed communities of practice amongst diverse stakeholders in conflict reduction, supporting information exchange and collective action to meet this shared goal. Through TACs and consistent communication among partners, this project leveraged the diverse skill sets and knowledge of partners and participants to further durable policies and products. Networks developed through this project have, and will continue to lead conservation innovation and impact in conflict reduction while also serving as a venue to disseminate important information across stakeholder groups.

Co-produced products: Through a deliberate process to lift livestock producer voices in guiding the direction of research and communications, this grant developed impactful products representative of the needs and perspectives of those most affected by predator conflict. The success of this grant would not have been possible without partnerships between livestock producers, members of the project team, and state and federal wildlife and land management agencies that worked in common purpose. Landowners and livestock producers maintain knowledge of the land and stewardship practices that are not often captured in scientific research, or elevated for peer-to-peer learning. Incorporating this knowledge is both important for representative applied science, and for development and diffusion of conflict prevention techniques. Products resulting from such a process are often more trusted and valued by producers because they reflect their perspectives and account for the complexities and challenges producers face as they steward the land. As such, these products are also the most likely to be shared among producers.

Cost sharing: This project has resulted in accelerated, and expanded funding opportunities for range riding, carcass management and fencing. NRCS chose to move forward with a turbo-fladry payment schedule within an existing practice available through EQIP, and an interim practice standard for carcass management. The Cow-CIG project laid the groundwork for two successful Regional Conservation Partnership Program applications, a $22 million investment to support the adoption of these conflict prevention techniques in five Western States. The project's large scope and success attracted additional funding partners – most notably a Western Sustainable Agriculture Research and Education grant that allowed year four of the field research, enabling robust data collection for final co-production in analysis and writing of two PhD dissertations and several peer reviewed publications assessing the research of the three techniques in spring 2026.

8. Acknowledgments

A huge thank you to Natural Resources Conservation Service for funding this work and supporting a direct need shared by landowners and their partners to help operate with predators.

We would like to thank the many landowners, livestock producers, and hands/range riders who offered their knowledge and experience to guide this project. This project would not have been possible without your time and thought in this collective effort.

The effort was possible through the support of USDA Wildlife Services, and the National Wildlife Research Center as well as state and federal wildlife management agencies including Oregon Department of Fish and Wildlife, Montana Fish, Wildlife and Parks, Arizona Game and Fish, New Mexico Game and Fish, the national Fish and Wildlife Service, and Washington Department of Fish and Wildlife, who generously provided data to improve our findings.

Thank you to the members of the research team, including Jared Beaver[1], Stewart Breck[2], Matthew Hyde[5], Kyran Kunkel[6], Rae Nickerson[7], Julie Young[7], Jay Shepherd[8] who guided and implemented novel and participatory research methods to explore the effectiveness of conflict prevention practices in question.

Thank you to the members of the Steering committee including Matt Collins[4], Erin Edge[9], Nate Owens[3], Gary Burnett[3], Alex Few[4], Emily Harkness[3], Bre Owens[10], Jay Shepherd[8], Jared Beaver[1], Jim Williams[3], and Stewart Breck[2], whose time and effort drove the success of this project. Thank you to Russel Talmo, whose expertise in applications of fencing to reduce conflicts supported this effort in many ways.

Thank you to Shawn Johnson and Travis Anklam of the Center for Natural Resources & Environmental Policy, University of Montana for your facilitation and support throughout this process.

[1]Montana State University, [2]USDA-APHIS-Wildlife Services, [3]Heart of the Rockies Initiative, [4]Western Landowners Alliance, [5]Colorado State University, [6]Conservation Science Collaborative, [7]Utah State University, [8]Conservation NorthWest, [9]Defenders of Wildlife, [10] National Grazing Lands Coalition, [11]Natural Resource Conservation Service.

9. Appendices:

Literature review of Carcass Management, Fencing, and Range Riding for Predation Management: A Document Created for the CoW-CIG

Authors: Rae Nickerson, Matthew Hyde, Stewart W. Breck, Julie Young, Jared Beaver, and Kyran Kunkel

General Background on Predation, Predation Impacts and Predation Management

Carnivore-livestock conflict remains one of the most contentious aspects of large carnivore conservation and management globally (Ripple et al., 2014). Conflicts can lead to threatened economic interests and human safety, fueled tensions, taxed relationships among stakeholder groups, and the lethal removal of vulnerable wildlife (Oakleaf et al., 2003; Madden, 2010; Muhly and Musiani, 2009; Breck, 2011; Scasta et al., 2017). Across the American West, the negative impacts oflarge carnivores, including wolves *(Canis lupus),* grizzly bears *(Ursus arctos),* and mountain lions *(Puma concolor),* are disproportionately borne by livestock producers. Depredation of livestock by carnivores results in direct economic losses to the producer (Treves & Karanth, 2003; Breck, 2004; Sommers et al., 2010). The cost of depredation is not exclusive to the fair market value of the animal. Livestock are often purchased, managed, and bred over generations for desirable traits and/or genetics (Anderson et al., 2014). Additionally, there are large time, energy, and resource investments required by livestock producers to mitigate conflicts with carnivores. Livestock owners may need to work additional hours, hire additional employees, change grazing areas, tum out dates, or communicate more frequently with wildlife agency personnel (Dickman et al., 2011; Hoag et al., 2011; Lee et al., 2017).

Conflicts may also result in indirect losses to livestock from predator-induced stress. Carnivores like wolves are opportunistic, pursuit hunters (Mech, 1970), meaning they actively search for, and chase down their prey. When livestock populate landscapes during the grazing season, successful predation attempts result in depredation (Oakleaf et al., 2003; Morehouse & Boyce, 2011), but unsuccessful attempts, or even predator presence alone may result **in** significant stress to livestock. Chavez et al. (2006) found that cattle depredations were much lower than actual visitation by wolves in a wildland-agricultural landscape matrix **in** northwest Minnesota, but it is normal for wolves to chase their prey much more frequently than the number of successful attempts (MacNulty, 2002). Stress, especially when chronic, can have high biological costs such as diverting behavior and biological resources away from immune function, reproduction, or growth (Heimbiirge et al., 2019; Steele et al., 2013; Ramler et al., 2014; Widman et al., 2019). Surviving cow-calf pairs in herds where wolf predation had occurred can have significant reductions in seasonal weight gain (Ramler et al., 2014). Over 80% of producers surveyed in one study believe indirect losses are as, or more damaging than depredation (Nickerson, 2021). Thus, the economic consequences of indirect losses may outweigh those of depredation.

Both behavioral and chemical responses to stress can result in indirect losses, but these responses may also create a negative feedback loop, where stress leads to a chemical response that then induces a behavioral response. Behaviorally related costs of predation include spending more time vigilant or traveling to avoid predation risk instead of time spent feeding, resting, ruminating, or reproducing (Brown et al., 1999; Kotler et al., 1994; Kotler & Holt, 1989). Known as Landscape of Fear Theory (Laundre et al., 2001), this well-established area ofresearch has primarily focused on wild ungulates rather than domesticated livestock (Schmitz et al., 1997; Laundre et al., 2001; Martin, 2011; Altendorf, 2011; Clinchey et al., 2013; Kohl et al., 2018). For example, Hunter and Skinner (1998) found that wildebeest increased their level of vigilance by 200% after a reintroduction of cheetahs and lions, and Laundre et al. (2001) found a similar relationship in Yellowstone National Park where cow elk in areas with wolves had higher rates of vigilance than mother elk in areas without wolves. These altered behaviors can lead to reduced seasonal weight gain, reduced reproductive rates, and injuries needing veterinary care (Steele et al., 2013; Ramler et al., 2014). Behavioral responses to stress can also result in higher overall costs to the operation, such as increased difficulty and risk handling livestock and using herding dogs, broken fences from attempted escapes from livestock, or culling additional cows with spoiled teats after losing their calves to depredation (Fanatico et al., 1999).

Chemical response alone, regardless of whether a behavioral response follows, may also result in indirect losses. Chemical stress increases in domesticated livestock caused by heat (Polsky & von Keyserlingk, 2017), transport (Schwartzkopf-Genswein et al., 2012), and slaughter (Edwards-Callaway & Calvo-Lorenzo, 2020) have been directly linked to insufficient digestion, immune function, meat and wool quality, and reductions in fertility (Heimbiirge et al., 2019; Rashford et al., 2010; Koolhaas et al., 2011; Clinchy et al 2013). An improved understanding of how predation pressure relates to chemical and behavioral stress responses can help livestock producers and policy makers identify the true economic losses associated with grazing on landscapes with large carnivores.

Most research on predator-induced stress has focused on either behavioral responses in wild ungulates or on chemical responses in domesticated livestock during non-grazing periods of the production process. However, a few studies have looked at either chemical, or behavioral responses to predation pressure in grazing livestock. Domestic cattle altered their rate of movement and habitat selection for much longer than wild elk populations after exposure to wolves (Muhly et al., 2010). Cattle responded to wolf predation with anti-predation behaviors like traveling farther or grouping together, behaviors that, although potentially beneficial for preventing depredation, may have significant indirect costs on reproduction and weight gain (Laporte et al., 2010; Clark et al., 2017). Increased stress hormones in grazing cattle have been detected at reduced distances to GPS-collared wolves (Valerio et al., 2021). Cortisol levels increased significantly in cows previously grazed among active wolf populations after simulating wolf encounters (Cooke et al., 2013). The establishment of wolf and grizzly bear populations coincided with higher susceptibility to illness and mortality in Wyoming calves (Sommers et al., 2010), and reduced weight gain and reproduction from cows pursued by wolves in Wisconsin (Fanatico et al.,1999; Lehmkuhler et al., 2007). These studies suggest cattle are chemically and behaviorally responsive to carnivore presence but have yet to combine these metrics. Measuring both responses may provide a more robust understanding of the relationship between predator induced stress and indirect losses (MacDougall-Shackleton et al., 2019).

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Carcass Management

Background

An assemblage of large carnivores extensively uses ranchlands in the Western U.S. Species such as grizzly bears *(Ursus arctos),* wolves *(Canis lupus),* mountain lions *(Puma concolor),* coyotes *(Canis latrans),* and black bears *(Ursus americanus)* can enter into conflict with humans and livestock systems on these ranchlands. Conflict between humans and carnivores occurs when large carnivores affect livelihoods in the form of direct and indirect impacts to livestock and, in rare cases, attacks on humans (Treves & Karanth, 2003). A strategy that has been popularized and promoted in the Northern Rockies in recent years is carcass management (Wilson et al., 2014). Livestock die of a plethora of natural causes, especially during calving and lambing season. Carcasses left on the landscape are an attractant for large carnivores, who can locate carcasses from miles away. Carcass management is the removal of dead livestock (herein deadstock) from critical places on ranchlands to reduce carnivore presence and future depredation. While this strategy shows promise, it is among the least studied conflict prevention strategies.

In this section we review and consolidate literature related to carcass management. Our intent is to understand how much evidence exists regarding whether: 1) deadstock attracts carnivores and creates more conflict; 2) removal of attractants reduces conflict; and 3) deadstock creates ecological traps for carnivores. We focus on how this practice relates to wolves and grizzly bears, yet we include studies that may involve more predators or present results that are generalizable across species.

Livestock deaths are an inevitable part of ranching. In the past, animals that died on ranches could be picked up at no cost by rendering plants, who processed non-consumable raw materials for other uses. But due to bovine spongiform encephalopathy (BSE) prevention protocols in the early 21st century and declining use of animal fats in products like soap, rendering plants began charging producers for pickup or to shudder (Kalbasi-Ashtari et al., 2008; Morehouse et al., 2021). As a result, many producers turned to on-ranch carcass disposal. This shift to local on-site deadstock disposal in the late 1990s and early 2000s coincided with the recolonization of gray wolves and grizzly bears to parts of their former range century following reintroduction of wolves in Yellowstone and rebounding populations of grizzly bears in Montana and Wyoming.

Most animals that die of natural causes on ranches do so during calving and lambing season, which is often in the winter/spring months (January-April) in the Northern Rocky Mountains. During this period, the ground is often frozen, making burying deadstock more difficult. Furthermore, larger animals like cows, bulls, and horses require equipment (e.g., backhoes) that not all producers possess. Therefore, deadstock is often left in the open or collected in a pile in open air, known as a bone pile.

Attractants and conflict

Ecologists have long known that anthropogenic attractants can influence diet, movements, and activities of both wolves (Fritts et al., 2003; Petroelje et al., 2019) and grizzly bears (Northrup et al., 2012; Wilson et al., 2006). Generally, wildlife seek to optimize foraging strategies to minimize energy expenditures while maximizing net energy gain (Perry & Pianka, 1997). In the case of carnivores, expected behavior would be to utilize food sources that reduce energy costs and risks, such as scavenging. Anthropogenic food sources provide a low energy cost subsidy to generalist species (Petroelje et al., 2019). In the case of carnivores, scavenging opportunities from dead livestock can be an important energy source. Anthropogenic food sources can present a risk to carnivores for many reasons: they can enter into areas inhabited by humans where they may threaten human lives or livelihoods (Wilson et al., 2006), become nuisances (Lischka et al., 2019; Wilbur et al., 2018), or be detrimental to their role in the ecosystem by not being limited by prey (Newsome et al., 2015; Parsons et al., 2022).

Bone piles are frequently located near the ranch headquarters or homes, leading to grizzly bears coming close to dwellings, calving pens, and other vulnerable areas. Wilson et al. (2006) demonstrated that a suite of attractants, among them deadstock, lead to conflicts between humans and grizzly bears because they enter areas with human activity and vulnerable livestock. This work was reinforced by a study showing how the increase in deadstock on ranchlands in Alberta, Canada, following policy changes led to an increase in negative interactions between humans and grizzly bears (Northrup and Boyce 2012). For carnivores, these areas can also become an ecological trap, an area where grizzly bears are attracted to but can end in further conflict and increased carnivore mortality rates (Wilson et al., 2006). Similarly, wolves frequent livestock carcasses when they are available (Morehouse & Boyce, 2017; Petroelje et al., 2019). A study of GPS-collared wolves in Wisconsin and Michigan found that wolves that had access to bone piles had smaller home ranges and less activity, and 22% of their diet was composed of scavenged livestock. Importantly, the authors found that wolf densities and group sizes were not greater in areas with bone piles (Petroelje et al., 2019). Previous studies in Minnesota found similarly that bone pile presence may lead to more visits to ranches (Fritts, 1982; Fritts et al., 2003), though one study found no difference between depredations on ranches with and without bone piles (Mech et al., 2000). Researchers studying gray wolves in Turkey reported that livestock depredation increases where carcass disposal is unregulated (Capitani et al., 2016), though this was only observed and not measured.

Depredation is costly to ranchers, but indirect effects of predator presence like reduced weight at weaning, decreased conception, and sickness may be more costly (Ramler et al., 2014; Steele et al., 2013). Scavenging opportunities on ranches increase the presence of carnivores near calving and lambing areas (Fritts et al., 2003), or effectively introduce carnivores to other anthropogenic food sources such as grains and fruits (Morehouse et al., 2021). The presence of carnivores due to deadstock may increase encounter rates with livestock and therefore increase the indirect impacts of predation on livestock. But to our knowledge, no one has evaluated how strong the link is between deadstock, carcass management, and indirect impacts on livestock.

Carcass management in practice

Carcass management was popularized in the western US by organizations like the Blackfoot Challenge in Montana and is now practiced by collaborative groups in Montana, Oregon, California, and new programs are emerging elsewhere. The Blackfoot Challenge, a place-based non-governmental organization in western Montana, is among the first and best-known implementers of carcass management. The Blackfoot Challenge built on existing community partnerships and collaboration to start a carcass management program in 2003 to respond to the expanding grizzly population in the area. Producers call a driver who collects the carcass and deposits it at a designated composting site, managed by the Montana Department of Transportation. As of 2017, 110-120 producers in four Montana counties participated in the program, which removed approximately 600 carcasses annually (Wilson et al., 2017). Importantly, carcass management is just one tool that the Blackfoot Challenge uses to mitigate conflict along with communication between neighbors, electric fencing of calving and lambing areas and range riders. Collectively, these tools have led to a 93% reduction in conflicts with grizzly bears (Wilson et al., 2014).

This conflict prevention strategy is unique because it requires collective action from a significant portion of neighbors to achieve the desired reduction in carnivore presence. Many carcass management projects are started by grassroot NGOs or other local organizations, but inevitably all initiatives require producers to self-report losses for pick up. Trust in the local organization is the keystone of participation, since many producers do not want others to know of their losses (Wilson et al., 2014). Furthermore, the use of any non-lethal strategy requires belief that the practice will work (Volski et al., 2021), and social acceptance is crucial to buy-in (Exp6sito-Granados et al., 2019; Hughes & Nielsen, 2018). Yet, few studies evaluate producer perception of conflict prevention strategies (Hyde et al., 2022; Volski et al., 2021) or social acceptance of a practice (Morehouse et al., 2021).

Gaps in research

Research demonstrates that deadstock can lead to further conflict with ranchers, but no research has been conducted to determine if removing carcasses reduces conflict with livestock. Intuitively, one would believe that if carcasses are strong attractants, that removing them will lead to reduced presence of carnivores on the ranch and near vulnerable livestock. Anecdotal evidence from wolves in Oregon (Petroelje et al., 2019) and grizzly bears in Montana suggest that it is effective (Wilson et al. 2014), but a variety of problems make studying carcass removal through an experimental approach challenging.

A hypothesis proposed by some ranchers is that the removal of scavenging opportunities will lead to more depredations, given that an important food source-especially during winter months or after hibernation-is being eliminated. However, this hypothesis assumes that carnivores are limited by natural food. While there is not research on the topic in the US or Canada, studies from other parts of the world contradict this theory. One study from Spain illustrates how carcass management may shape wolf diets. Following the shift to obligatory carcass removal to prevent BSE, researchers found that wolves shifted their diets to native ungulates in the absence of scavenging opportunities on livestock carcasses (Lagos & Barcena, 2015). Another study from Southwest Alberta demonstrated that wolves scavenged and consumed more livestock from April to October, rather than during winter months, providing evidence that bone piles may not be as important for scavenging during the winter (Morehouse & Boyce, 2011). However, further research on grizzly bear diets would be necessary to understand how reducing the availability of deadstock would affect their diet.

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Fencing

History of the use off encing for livestock management in the US

In 1907, an experiment began in the Wallowa mountains in Eastern Oregon that would forever influence the relationship between fencing and carnivore-livestock interactions. The US Department of Agriculture's Bureau of Biological Survey, the newly created US Forest Service, and the Bureau of Plant Industry set out to create a coyote-proof fence. The goal of the fence was to reduce labor needs (i.e., herders) and allow sheep to graze freely. The fence encompassed four square miles in the Imnaha National Forest and was created with one strand of barbed wire on the bottom to discourage predators digging, wire mesh in the middle, and two strands of barbed wire at the top secured by stouts posts and a diagonal cross-post. A hunter with hounds cleared that area of all predators, then patrolled the area daily to remove any remaining predators when possible. A band of 2,209 sheep were moved to the fenced pasture in 1908 to begin observation. The scientists conducting the experiment recorded losses and weighed 20 lambs of "average size", comparing them with 20 lambs from outside the fence (Sayre, 2015).

The experiment was ruled a success by its administrators: lambs inside the fence weighed 5 pounds more on average, losses to predators were only 0.5% compared to 1.4-3% outside the fence, and apparently sheep inside the fence needed 50% less pasture by area. The cost-benefit of the fence, however, was not apparent. It had cost $6,764.31 (excluding the hunter) to build the fence (equivalent to $216,486 in 2023). The scientist behind it claimed that that cost could be recovered in six years-but this high cost of fencing could only be justified if labor costs were removed and predators were effectively exterminated. The USDA signed onto to the results, and decades of fence building and predator control ensued. The fence design from Wallowa, however, was forgotten and replaced by cheaper four-strand barbed fences (Sayre, 2015). This general system of grazing livestock within fenced areas and controlling predation through lethal control was a major factor in driving techniques for rangeland management and for developing fencing throughout the United States. Fences have been adopted around the world to contain livestock in designated areas and to reduce predation losses.

To deter predation by large carnivores, electric fences are perhaps the most common and important tool. The first known use of electric fence was in 1938. Storer et al. (1938) sought the use of electric fence to defend apiaries used for fruit production in the Sacramento-San Joaquin Valley that were moved to the Sierra Nevada in the summertime. The authors state " ... nowadays some equally complex situations are arising in the field of economic zoology where the activities of different species of animals touch diverse human interests. Thus, the evolution of agricultural crop production in the lowlands of California has now affected the wild black bears in the Sierra Nevada, and the aid of an electrical engineer was necessary in the chain of adjustments that had to be made!" Five strands of wire were placed at 6, 14, 24, 35, and 48 inches above the ground and were charged with a battery. Attractants were placed within the fence barrier and researchers observed black bear behavior and whether they breached the fence. The shock of the electric current was sufficient to scare off black bears, and the researchers provided insight on how best to design the fence.

Modern predator-proof fencing

Despite its long history and ubiquitous use, fencing to deter predators suffers from a gap between what is researched and what is implemented. In science, this is typically referred to as a knowledge-action gap (Ruppert et al., 2021), whereby scientists build knowledge and there is limited implementation of that knowledge on the ground. However, in the case of fencing for predators, the innovation likely occurs at the action stage, and the knowledge creation has yet to catch up.

We reviewed > 50 academic articles on fencing worldwide to deter predators. Just 18 of those articles included information to reconstruct the design that they tested. Wolves were often the target predator or one of the targets, whereas grizzly bears were less frequently targeted. Adoption rates are not included, and most articles consist of short-term field trials, typically for less than one year. Of those 50 articles, only three included producer input in the design. Our previous discussions in the Technical [Fencing] Advisory Committee indicate that strategies designed outside of the agricultural community lack practicality when applied to production systems (Hyde et al., 2022). Furthermore, research shows that producers put more faith in strategies communicated to them by other researchers (Volski et al., 2021).

A small number of commonly used fence designs to deter predators have sufficient literature to review. Below, we include the two most relevant for wolves and grizzly bears. It should be noted that there is abundant literature on best fencing designs for how to manage livestock but that literature is not included here.

1) *Fladry:* Fladry is a series of flags tied around a wire to form a linear barrier. The use of fladry can be traced back to wolf hunting in Poland, whereby hunters would tie the line around trees so that wolves would not exit the area, and thus they would be funneled to a small opening where hunters waited (Okarma, 1993). Wolves and canids like coyotes are neophobic, meaning that they avoid new stimuli, and thus do not cross the line of flags (Young et al., 2015). Experimental tests have demonstrated that fladry is effective for 60 days for wolves (Davidson-Nelson & Gehring, 2010; Iliopoulos et al., 2019; Musiani et al., 2003) and for coyotes (Windell et al., 2022). Its effectiveness can further be improved by electrifying the wire that the flags are tied to, which has been to be effective for much longer (Lance et al., 2010) or by decreasing the spacing between flags to prevent passage by coyotes for longer (Young et al. 2019). Fladry is ideally used during calving or lambing season because of the short time period when canids are deterred by it. Often, it is applied outside of an existing fence as an additional deterrent.

2) *5+ wire electric fence:* Electric fences may be the most commonly employed predator-deterrent fence by ranchers in the US and conservationists worldwide to reduce depredations. Designs for the fence (energy source, post material, spacing, pasture size) vary greatly based on available financial resources and local conditions. However, a number of studies have shown that electric fences can deter an assemblage of predators (Bruns et al., 2020; Khorozyan & Waltert, 2019; van Eeden et al., 2018).

Next steps

Our co-production process with producers and practitioners and preliminary research indicate that fence designs are nuanced to the topography, climate, and other environmental conditions of the operation. This nuance is seldom captured in academic literah1re, but some studies point to the importance of gray literature as a sort of environmental evidence for predator deterrence (Khorozyan, 2022). This topic has yet to be explored in the case of effectiveness and adoption of predator fences in the US. We are currently conducting a full review of evidence of fencing effectiveness and matching those results with producer-reported results.

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Range Riding

Background and literature focused on range riding.
Conflict prevention tools, such as electrical fencing, fladry, carcass removal, and/or livestock protection dogs, can reduce direct and indirect losses associated with operating alongside large carnivores (Young et al. 2018; Shivik et al. 2006; Breck et al., 2004). Range riding, or the use of human presence where livestock are grazed to deter predators, has been used for millennia by pastoralists across the globe (LaRocque, 2014), although American settlers began turning out cattle to graze freely on range with little to no supervision, leading to the open-range ranching that is common in the USA and Canada today (Stewart, 1991). Range riding is the only conflict prevention tool that applies direct human presence via the rider who may be on horseback, in a vehicle, on an ATV, walking, or biking (Bangs et al., 2006; Parks, 2015; Wilson et al., 2017). Riders not only provide presence, but they can also provide spatial and temporal adaptability as the rider makes decisions in direct response to the behaviors of predators and livestock regarding if, when, and how to manage livestock, deter predators, and monitor the activity of both (Wilson et al., 2017). There is evidence that human presence and activity can alter predator spatial distributions (Chavez et al., 2006; Hebblewhite et al. 2005; Muhly et al. 2010) and limited evidence that riders reduce wolf depredations of cattle (Ogada et al 2003, Wilson et al., 2017 Louchouarn NX, Treves A. 2023) due to few studies that link range riding and depredations.

Range riders are also flexible, meaning they can change how they respond to, and attempt to prevent conflict based on observations and circumstances. This ability is important, because although predators are neophobic, they are also incredibly adaptable, and tools like fladry, fox lights, and rag boxes with little to no variation after deployment may only be effective for short periods of time (Bangs et al., 2006). These short-term tools are also limited by other factors related to technology and capacity (rag boxes require wolves to be radio collared, and fladry requires constant maintenance) pasture/allotment size and location (fladry and rag boxes are likely inappropriate for pastures larger than ten acres), and cost (Breck et al., 2004; Shivik et al., 2004). Similar to range riders, livestock guarding dogs may be another adaptable nonlethal tool for sheep herds that typically stay grouped together, but less so for cattle who generally disperse over large areas (Bangs et al, 2006; Kinka et al., 2021).

Riding may also provide additional benefits both directly and indirectly linked to preventing predator conflicts. By having riders on the landscape protecting livestock from depredation, other operational needs can be identified (e.g., sick or injured animals needing attention, downed fence, or previously undetected depredations). This additional livestock monitoring may lead to improved management, potentially resulting in healthier livestock, landscapes, and more satisfied producers (Barnes, 2015; Parks, 2015). Riders can use various management techniques to encourage herds to forage in higher densities, not only reducing the risk of predation, but also improving rangeland health and overall grazing capacity (Barnes, 2015). Riders may also reduce predator-induced indirect losses in livestock by reducing the impact of predator presence and pursuit, furthermore, encouraging foraging efficiency, grazing in higher quality habitat, and decreasing time spent vigilant (Howery & DeLiberto, 2004). Using a rider may also provide off-range benefits. Producers have noted that social benefits, in addition to conflict prevention, drove their decision to use a range rider, including the influence of a rider program on public perception, a sense of empowerment, reduced stress, and trust building (Parks, 2015). In this sense, riding can be an adaptable, holistic non-lethal tool unique to other conflict prevention tools.

While human presence may be advantageous to reducing livestock depredation, it also presents challenges for studying the effectiveness of range riding because riding strategies and styles vary widely depending on the rider, operational or environmental contexts, an operations capacity, and the specific needs of a producer (Parks, 2015). For example, some riders prioritize locating and hazing predators, while others believe staying near the herd provides the best protection against predator conflict (Parks, 2015). Some riders ride daily, while others ride less frequently. Occasionally riders ride at night when predators are most active (Muhly et al., 2011; Chavez et al., 2006), but due to practicality and human safety concerns, most riders ride during the daylight hours. Some riders focus exclusively on providing human presence around the herd, while others focus on risk reduction activities such as searching for injured or sick animals, or detecting depredations that might act as predator attractants (Wilson et al., 2017). Additionally, some riders are hired by the producer directly as ranch hands, while others work for rider collaboratives, often riding for multiple producers across many allotments (Parks, 2015). Although most collaboratives share organizational components like a sponsor, collaboration among several organizations, a funding mechanism, feedback mechanism, and structure including a supervisor, the producer(s), and the rider(s), the context, program focus, and scale of these programs varies (Parks, 2015). Riders also vary in their level of experience with cattle handling, which may or may not influence their overall effectiveness. Of the few existing studies on range riding, none examined the influence of varied rider behavior, such as frequency, duration, time of day, proximity of the rider to the herd, or whether riders focus on herd management or predator detection. Quantifying only if a rider was deployed and not *how* a rider was deployed means existing studies are limited **in** their explanatory power. To understand the effectiveness of range riding as a conflict prevention tool, a more detailed investigation of these behaviorally related variables is needed.

In addition to the above, the relationship between riding and indirect losses has not been explicitly evaluated. This uncertainty surrounding riding's effectiveness and influence on the broader systems creates a challenge for the individuals, non-government organizations, agencies, and producers funding riders. Ranchers are hesitant to adopt conflict prevention tools like range riders because of their unknown effectiveness and cost of implementation (Scasta et al., 2017, Shivik, 2006), and perceptions regarding a tool have shown to be stronger drivers of tool use in the agricultural community over objective calculations of efficacy (Marker et al., 2005, Armitage & Conner, 2001; Willcox et al., 2012, Borges et al., 2014). For example, challenges related to trust, open communication, a lack of stable funding, and a lack of evidence on riding's effectiveness negatively impact producer perceptions ofrange rider programs (Parks 2015). Comprehensively quantifying the effectiveness of range riders at the operational and landscape scales is needed, and using both quantitative and qualitative methods will help to ensure tools remain relevant, actionable, affordable, and practical for the producers using them.

Next Steps

There is an on-going study to evaluate whether range riders reduce direct and indirect losses, as well as evaluating the relationship between riders, operational needs, and the health, productivity, and functionality of the broader ecosystem they ride in. Once completed, this study will help fill the research gap on range riding and help sustain working lands, connected landscapes, and native species by exploring whether range riding benefits predator-livestock conflict reduction, livestock management, and rangelands management at various scales, and its potential to be a holistic and adaptive conflict reduction tool.

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Reducing Risk on the Range: Non-Lethal Practices for Managing Carnivore-Livestock Conflicts

Purpose

Non-lethal predation risk management practices, including range riding, carcass management, electric fencing/fladry, and associated practices can be incorporated into livestock production systems to benefit both agricultural operations and wildlife. These practices:

- foster flexibility in grazing implementation,
- maintain adequate separation of carnivores and livestock to decrease both livestock and wildlife injury and mortality, and
- lead to more permeable working lands that allow for wildlife movements within and across connected landscapes.

This publication provides a guide to evaluate livestock risk to carnivore predation over space and time; gives background on the forms and functions of range riding, carcass management, and electric fencing/fladry; and outlines principles to guide practice implementation.

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Acknowledgments

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Introduction

Across the western US, iconic wildlife like grizzly bears and wolves share lands with humans and livestock. This comes with a high potential for operational and resource challenges for livestock producers and natural resource professionals. Grizzly bears, wolves, and other carnivores may injure and kill livestock causing significant production losses. Responding to these challenges requires additional time and resources from land stewards, including ranchers and wildlife managers.

Successful conflict reduction, an often-used term for a comprehensive approach to managing the risk (ecological, financial, and social) that can be associated with shared landscapes, involves collaboration, conflict prevention, lethal predator control, and compensation (for direct and production losses). Conflict prevention, as an element of conflict reduction, incorporates actions that remove or limit access to anthropogenic attractants, signal human presence to carnivores, and/or monitor and manage livestock in areas where predators are present. Specific conflict prevention practices, including range riding, carcass management, and electric fencing/fladry can be incorporated into ranch management systems to benefit both wildlife and agricultural operations. These practices work to maintain adequate separation between carnivores and livestock in space and time, avoiding the ecological traps that can increase mortality of carnivores, and therefore create more permeable habitats that allow for wildlife movements within and across connected landscapes.

While there are a host of practices that can be used to manage predation risk, this note focuses on range riding, carcass management, and electric fencing/fladry due to their eligibility for cost-share within NRCS programming. Range riding involves monitoring livestock-predator interactions and activity to minimize conflicts and improve range utilization and forage quality. Carcass management focuses on securing, removing, and final disposal of livestock carcasses and bone piles that act as attractants to carnivores. Electric fencing and fladry serve to establish a temporary or permanent barrier between livestock and carnivores. These practices should be considered in addressing resource concerns such as terrestrial habitat limitations or other conditions that elevate wildlife-livestock conflict, or forage imbalance or other grazing management limitation that reduces flexibility in the grazing system adapted to predation risk.

This publication provides guidance on evaluating predation risk to livestock over space and time; a background on applications of range riding, carcass management, and electric fencing/fladry; and management principles to guide effective deployment. The intent of this guide is to support carnivore-livestock conflict reduction, although implementation of these practices can result in co-benefits including augmented livestock productivity, forage stand improvement, wildlife habitat enhancements, and riparian zone management.

The information is conveyed through two frameworks: 1) the planning framework for predation risk management that outlines strategies to implement and adapt over time; and 2) the risk assessment framework that works to understand when and where there may be risk of depredation within a specific landscape.

This guide includes case studies that highlight lessons learned through the process of practice implementation and continued management. Each facet of this note draws from three years of co-production, including meetings with landowners, livestock producers, wildlife biologists, partner organizations, Tribes, and federal and state agencies. It represents both knowledge and experience gained on the land through carnivore-livestock conflict management and research.

This Tech Note is intended to serve as a guide for conservation planners, landowners, and other partners **in** stewarding landscapes where people, livestock, and wildlife all thrive; where effective and practical predation risk management activities work in concert with complimentary state and federal policies/programs; and where economic mechanisms support resilient, biodiverse working lands.

The Planning Framework for Predation Risk Management

A diverse group of stakeholders contributed to the development of the planning framework for predation risk management. This planning framework, expanded upon later in the document, aligns with the Natural Resource Conservation Service's widely applied nine-step conservation planning process and is intended to serve as a guide for landowners, conservation planners and other partners in identifying community and ranch-specific approaches to reduce conflicts and manage landscapes for multiple production and conservation values. We break down this framework into six components:

1. Know your context; including species, place, time, disturbance and land use
2. Identify goals and objectives
3. Context specific application
4. Communicate for success
5. Integrate emerging strategies and complementary technology
6. Continue to assess risk, evaluate outcomes and adapt activities

Predator Ecology

This section provides an overview of factors that ranchers and natural resource professionals may consider regarding predator ecology and behavior relative to livestock predation risk. We divide this topic into five sections corresponding with the risk assessment framework: Species, Place, Time, Disturbance and Land use as a means of highlighting different categories of predation risk to livestock. Importantly, this section should be considered as an idea generator for livestock producers and conservation planners regarding predator behavior and predation threat to livestock. How these ideas apply to local landscapes and the type of predators will likely vary and thus it is important that producers and planners develop local knowledge applicable to the specific ranch and landscape.

Species

There are a variety of North American carnivores that can prey on livestock including grizzly bears, black bears, wolves, coyotes, and mountain lions. The type of livestock that each predator can prey on is determined by its size and hunting ecology. Each predator species will employ one of two strategies for hunting: ambush predation or chasing predation (aka coursing predation). Wolves are excellent examples of coursing predators; wolves run at prey and attack flanks and legs until there is an opportunity to attack the neck and face. How wolves hunt livestock and whether the livestock behave similarly to native ungulates is poorly studied, but it is likely wolves key in on similar cues (i.e., injury, weakness) from livestock as native ungulates. This may be relevant if livestock are skittish and **run** at the sight of predators, a behavior that may make them more susceptible to predation. Stalk-ambush predators like mountain lions generally do not chase their prey for long distances, preferring to attack from cover and kill prey quickly by biting through the skull or the vertebrae or biting in the windpipe area of the neck. Bears are a mix between ambush and chasing predators and they are efficient scavengers as well.

The distinction between ambush and chasing is important to understand both direct (depredation) and indirect impacts on livestock operations. Predators that chase their prey, like wolves, may cause elevated stress levels which can lead to reduced weight gain, lower pregnancy rates, and other injuries. Ambush predators likely cause fewer indirect impacts but may have higher success rates of attacks that result in dead livestock. However, indirect impacts are an understudied topic in carnivore-livestock conflict. Livestock carcass scavenging, either by random encounter or sympatric carnivore kill displacement is also common for both species of bear.

Predator demographics like sex and age likely influence risk of preying on livestock, however, specifics of this subject are generally poorly studied for most predator species. Typically, males are larger than females for all North American predators. Males may pose a greater threat, though females will also kill livestock. Social predators, such as wolves, hunt in groups so both males and females play important roles in taking down prey. The age of predators can also impact their relative threat to livestock. Juvenile predators often disperse in search of opportunities to establish their own territory. These young individuals may not be adept at hunting native ungulates, and therefore select for prey species that may be easier to capture and kill, such as livestock. A similar pattern of seeking livestock may form in older predators if they are evicted from a pack or territory or are less adept at preying on native ungulates.

The process of learning to prey on livestock is a final important biological consideration. Individuals develop a search image for what they consider to be prey through a process of learning from other conspecifics (namely mothers or pack members) as well as experimental learning (i.e., attacking different prey species). This process is relevant because individuals that do not develop a search image for livestock will oftentimes not be a problem or threat to livestock. When these types of individuals are removed, new individuals settle in the vacated space that may have developed a search image for hunting livestock. However, given enough time and encounters with livestock, any individual animal could learn to hunt livestock instead of native prey. Once this learning process has occurred, it is generally more difficult to stop individual predators from pursuing livestock with nonlethal tools.

Mountain lion, wolf, and coyote densities are limited by their behavior of maintaining, marking and defending home areas. They may occasionally overlap in space with other individuals or groups of their species, but not necessarily **in** time. They avoid each other for most periods of the year. Exceptions, of course, are breeding periods, family groupings, and random encounters during travels. **In** some cases, male mountain lions or wolves confronting conspecifics is a result of direct territorial or pack interactions. These interactions are often more common **in** areas of abundant food resources. Predators spend more time in areas with access to food within their territories and may overlap in space and time in these areas with other predators. Thus, human related attractants (e.g., livestock carcasses) may influence the location of resident animals relative to the attractant, potentially increasing interaction rates both among predators and with livestock.

The same management actions may have different outcomes for different predator species because of their social and spatial structure. If a mountain lion begins depredating on livestock or other privately owned animals, lethal removal of the individual causing the conflicts may alleviate the problem. For wolves, lethal removal of the entire resident pack may also temporarily alleviate the issue. However, individual removals from a wolf pack may ultimately exacerbate the problem as many wild canids respond reproductively to disturbance. The livestock-habituated survivors may respond by producing more pups, potentially initiating the depredation cycle again. Grizzly and black bears, on the other hand, overlap seasonally in both time and space, and are not necessarily behaviorally limited. Local attractants such as livestock carcasses, grain bins, or other human-related attractants may create temporarily higher densities of resident bears and attract neighboring individuals, thus increasing the potential risk of additional depredation events. Removing carcasses, when possible, may reduce further depredation events from predators.

A final consideration for all predator species is their individual management profile (e.g., threatened/endangered species versus a game animal, versus a pest species). The management profile of each species is primarily governed by each state or Tribe unless the species is federally listed, in which case the management authority is the US Fish and Wildlife Service (USFWS). Understanding the management profile and how it varies from state to state is important, as such designations impact if and when predators can be hunted or lethally controlled by management agencies.

Key points

- North American carnivores, including grizzly bears, black bears, wolves, coyotes and mountain lions, can prey on livestock based on their size and hunting strategies (ambush or chasing).
- The distinction between ambush and chasing predators has direct and indirect impacts on livestock, such as elevated stress levels and potential injuries, which vary by predator species.
- Predator demographics, like sex, age, and learning processes, influence their threat to livestock. Young and inexperienced individuals may target livestock for easier prey.
- The social and spatial behavior of predators, as well as human-related attractants like livestock carcasses, can influence interactions among predators and with livestock, requiring different management strategies based on species and circumstances.

Place

Each site or region has a unique set of abiotic and biotic conditions influencing predation risk. It is safe to say that some areas in a landscape are riskier for livestock than others but developing blanket statements that apply across all predator species and across all environments is impossible. Instead, we provide some ideas and generalities regarding space that livestock producers should consider when thinking about predation risk; the biotic and abiotic components of their environment may influence this risk.

Abiotic aspects of each site are the nonliving features in the ecosystem that influence the behavior and activity of predators. Major categories to think about are landscape features, water sources, and terrain/topography. In all cases the goal of understanding what abiotic features influence predation risk is to help minimize predator-livestock encounter rates. Landscape features are things like mountain ranges and mountain passes, canyons and river bottoms that can influence the movement and travel patterns of predators and in some cases funnel multiple individuals into the same location. Predator species will also utilize game trails and even roads given they are not heavily used. The presence of water can increase predation risk in grazing systems that are drier or when native game species congregate at areas with water.

There are also abiotic aspects of the environment that influence biological aspects of predators. For example, ambush predators are most successful at killing prey in steep terrain or in darkness, whereas coursing predators are more successful in flat or rolling hills day or night. Further, predator species will select certain places to den and rear young depending on the type of predator and its preferred environmental factors. Knowing what type of environments are more likely to have denning predators can help in avoiding those areas during critical time periods when adults are provisioning young and may be less mobile.

Biotic aspects of an environment are those living factors that can influence predator behavior and movement and therefore increase predation risk. Biotic factors include vegetation, native prey species and people. Density of vegetation can afford greater cover for predators and therefore pose more risk to livestock. Dense vegetation is especially advantageous to ambush predators. Often some of the riskier environments are riparian areas because they have higher density of vegetation as abiotic factors like water and microclimate that can be attractive for predators for both habitat connectivity/travel ways and foraging events.

Riparian areas can be very attractive to livestock as well, thus creating a dynamic that compounds risk. For omnivores like bears, considering the vegetation and the availability of fruit or nuts can be important at certain times of the year when some areas with highly productive vegetation can attract multiple individuals. Aspects of native prey species can influence space and predation risk with the primary point being there are things prey species do that influence the behavior of predators. The congregation of prey species in particular locations can attract predators and, therefore, potentially increase the probability of interacting with livestock. Some examples include, elk and deer calving areas, winter ranges, spawning of fish and presence of high densities of insects.

A final critical biotic aspect to consider is what people are doing and how predators respond. It is critical to understand the extent to which human activity increases attractants that can bring different predator species into places and increase predation risk. Examples of this include the presence of a dead animal pit, trash piles, and unprotected crops like fruit. We encourage livestock producers and conservation planners to think about the abiotic and biotic factors influencing predators within the operation and landscape of focus.

Key points

- Predation risk in livestock varies across different sites and regions due to unique abiotic and biotic conditions.
- Abiotic factors, such as landscape features, water sources, and terrain, influence predator behavior and movement, impact predation risk.
- Ambush predators thrive in steep terrain and darkness, while coursing predators prefer flat or rolling hills, affecting when and where encounters with livestock may occur.

- Biotic aspects, including vegetation, native prey species, and human activities, also influence predator behavior and movement, with factors like dense vegetation and attractive food sources increasing predation risk.

Time

There are two primary considerations related to time that influence predation risk for livestock producers: seasonality and time of day. Seasonality refers to the different stages in the annual life cycle of predators. For bears, the most important aspect of their seasonal life cycle is their timing for hibernation. During late fall, bears generally stop eating and move into their dens where they will stay until spring. Upon emergence, individuals generally begin foraging on fresh vegetation, therefore posing less of a threat to livestock producers. Though much of the meat consumption that occurs by bears in spring is that of scavenging off dead animals from the winter, bears may still take advantage given an opportunity to prey on livestock.

For bears that will readily take advantage of a variety of food sources, there are other considerations related to seasonality. Important sources of food can include the ripening of various fruit, nuts/seeds, and the seasonal activity/availability of insect species like ants and moths and other native animals like spawning fish and ungulates like elk and deer. This diversity of food available to omnivores does not exist for obligate carnivores like wolves and mountain lions. Obligate carnivores must hunt year-round to survive.

The risk oflivestock predation by both obligate and omnivorous carnivores is likely reduced during certain seasons when native prey become more susceptible to predation. These include spring ungulate calving periods and winter. Harsh winter conditions can make ungulates more susceptible to predation or to mortality from other causes that provide carrion on the landscape for predators to consume. Predation on native ungulates during the late summer and fall can be challenging because young ungulates are old enough to escape predation and environmental conditions are such that ungulate forage is plentiful, resulting in expanded spatial scales of their grazing areas.

During denning, wolves are closely tied to the den site. If livestock are located near the site, the potential for conflict may increase. Depredations usually increase in late summer as the pups become bigger and more mobile and the pack moves to using rendezvous sites. Time of day is the other important variable. While predators can be active at any time of day, hunting behavior often peaks at dawn or dusk when wild prey species are most active. This is often the same time of day when livestock are grazing and may spend less time vigilant to threats. It can also be a difficult and potentially dangerous time of day for humans, such as range riders or herders, to see predators in areas with livestock. Combined, this creates a more vulnerable time of day for livestock to be depredated.

Key points

- Seasonality affects predation risk for livestock, influenced by the annual life cycle of predators.
- Omnivorous predators like bears have diverse food sources, including fruit, nuts, insects, and spawning fish, which can reduce their predation on livestock during certain seasons. In contrast, obligate carnivores like wolves and mountain lions rely on hunting year-round.
- Predation risk on livestock is reduced during spring ungulate calving periods and winter when harsh conditions make native prey more vulnerable to predation or mortality.
- Wolves, tied to den sites during denning, may pose a higher risk to nearby livestock as pups grow and become more mobile. Wolves are most active at dawn, dusk, and night, coinciding with times when livestock are often less vigilant.
- Time of day is a critical factor, with predators being most active at dawn and dusk, when both wild prey and livestock are active. This creates a vulnerable window for livestock, especially when human observers like range riders have difficulty spotting predators during these times.

Disturbance

There are many types of ecological and human disturbances that affect wildlife populations, which in-turn, can affect depredation risk to livestock. Ecological disturbances, including fires, rain, snowstorms and drought are increasing in intensity and frequency alongside changes to earth's climate. Human disturbances, including consumptive and non-consumptive recreation, light and noise pollution and management of wildlife, are also increasing in frequency and intensity. Thus, the way animals respond to temperature and precipitation fluctuations or disturbances is changing and may lead to increasing levels of conflicts with humans.

Lethal removal of carnivores - whether as a management action or through recreational harvest - can have potentially positive and negative impacts to livestock predation risk depending upon how, when and where it is implemented. For example, partial pack lethal removal of wolves or removal of individuals not causing problems may do little to impact predation risk to livestock and possibly even increase predation risk. While full pack removal of known depreciating wolves and removal of individual bears known to be depreciating on livestock can reduce depredation temporarily.

The idea that recreational hunting of predators decreases livestock predation risk is not widely supported **in** scientific literature. Access for recreational hunters to specific agricultural landscapes is quite variable and can be a difficult wildlife population management challenge. It is likely that an important aspect of whether recreational hunting is effective or not for reducing depredation rates is whether hunting can meaningfully reduce the predator density and such actions may or may not be a goal of the hunting activity. A poorly studied question is what the effect of hunting has on predator behavior and whether such activity creates individuals that are more wary of people. If this is the case, then such hunting activity could reduce predation pressure assuming that human presence is, and/or other conflict prevention techniques, are integrated into the grazing plan.

Importantly, lethal removal or harvest should not be considered a permanent solution but rather part of an integrated suite of actions used to reduce predation on livestock with the most important tools being those used to prevent livestock depredation. Lethal control of predators may remove individuals that cause conflicts and therefore reduce conflicts temporarily. However, in most cases conflicts increase in subsequent years following social-structure disruptions. This is likely because new animals unfamiliar with the area may seek out easy prey items like livestock while becoming familiar with the local habitat and prey base. This negative feedback loop may explain scenarios with long-term chronic depredation.

Noise, light, and chemical pollution have repeatedly been shown to alter animal behavior. These alterations are wide-ranging but often relate back to increased stress and decreased health of the animals affected by pollutants. Only a few studies have measured links between animal behavior and pollutants in carnivores, but these trends are also prevalent and often result in increased human-wildlife conflicts. For example, urban coyotes in poorer health were most likely to cause human conflicts in a city. Similarly, carnivores are negatively affected by noise and light pollution, with some evidence suggesting increased rates of predation in carnivores experiencing these sources of pollution. In areas where carnivores overlap with livestock, this could cause increased depredation.

More people are discovering the joys of recreating outside. Whether they are hunting, fishing, riding ATVs, hiking, or birding, wildlife are aware of our presence and often respond in ways similar to when they encounter predators. For example, elk dramatically shift their space use in areas of high recreation use - a trend seen whether it's hikers on trails in Washington or hunters in Wyoming. Carnivores are also known to change their space and timing of space use to avoid humans. They also use more energetically costly paths to move around the landscape when humans and human-made structures are present. This loss of energy means they are likely needing to hunt more food to recuperate lost calories. Since most people recreate in areas without livestock, it is likely that our activities are pushing prey and predators into areas with livestock and could lead to increased depredation.

Indirect human impacts, caused by climate change, are also impacting predators and prey in ways that could increase depredation conflicts. Extreme weather events can reduce health and increase stress in carnivores and their prey. Prey may shift their space use to find new forage when drought reduces forage or storms and fires damage forage. Carnivores will follow prey or risk starvation. Movement of carnivores could result in novel areas of overlap with livestock since livestock are also seeking areas with forage and good forage areas will be reduced after severe weather events.

Key points

- Lethal removal of carnivores can have mixed effects on predation risk, with partial pack removal often being ineffective, while targeted removal of depreciating individuals can reduce conflicts temporarily.
- Recreational hunting may not significantly reduce predation risk to livestock, as its effectiveness varies based on factors like predator density and behavior changes. The impact on predator behavior is poorly understood.
- Lethal removal or harvest should be part of a broader strategy to reduce predation on livestock, as it may temporarily alleviate conflicts but often leads to increased conflicts in subsequent years due to social-structure disruptions.
- Noise, light, and chemical pollution can alter animal behavior, potentially increasing human-wildlife conflicts, including livestock depredation, when carnivores overlap **with** livestock.
- Outdoor recreation activities by humans can disrupt wildlife behavior and space use, potentially pushing prey and predators into areas with livestock, increasing depredation risk.
- Climate change-induced extreme weather events can impact carnivores and their prey, leading to changes in space use and potential overlap with livestock, exacerbating depredation conflicts.

Landscape/land use

Maintaining predators on the landscape that are naive or afraid of livestock can be enhanced by how the land is used. Minimizing the presence of deadstock, utilizing human presence through practices **like** herding and range riding and using the landscape in ways that minimize encounters between livestock and predators can reduce the potential of predators learning to prey on livestock.

Landscape configuration and features can be important determinants of where predators will move in relation to livestock. River corridors are often prime habitat for the movement of grizzly bears, for example. Livestock that are grazing or resting in these corridors may be especially vulnerable to predators. Landscape features are also relevant to predation management tactics. For example, electric fences or fladry may not work to deter predators because of divots or gullies where predators like wolves can dip below the bottom wire. Additional care should be taken to fence these areas.

Key points

- Managing naive or livestock-averse predators can be influenced by land use practices.
- Reducing the presence of deadstock, employing herding and range riding techniques, and minimizing livestock-predator encounters are effective strategies.
- Predators respond to landscape features which can influence predation risk.

Predation Risk Management: Tools and Applications

A variety of risk management practices limit conflicts by making livestock less vulnerable to predation (range riding), creating defensible spaces (fencing), or securing attractants including deadstock (carcass collection). These practices can support wildlife habitat suitability and permeability for large predators or other wildlife species within working wild landscapes.

This section offers an overview of the form, function, and applications of range riding, carcass management and different fencing scenarios as well as practices and enhancements for conservation implementation.

Range riding

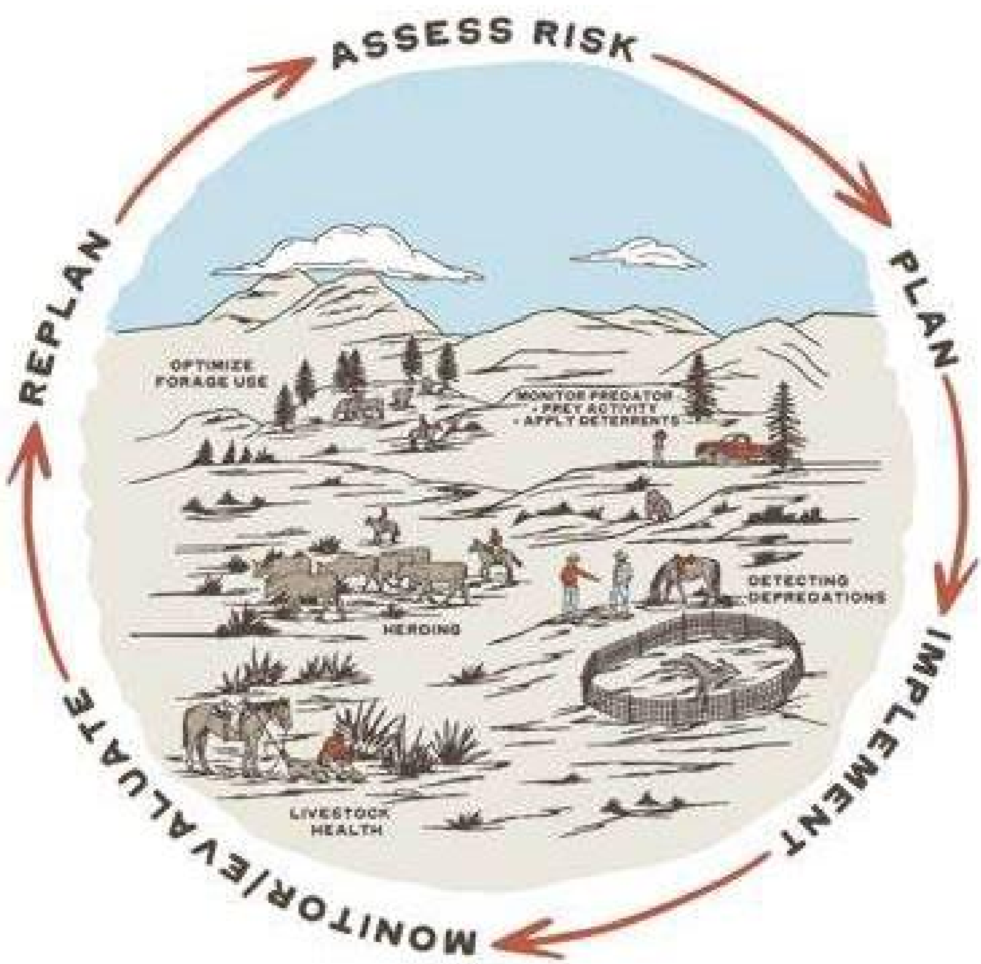

Figure 1: Range riding

Range riding is a flexible tool applied within an adaptive management structure making it beneficial for use in Western landscapes, which are expansive, ecologically and topographically diverse and subject to significant annual variations in weather and productivity. The overarching goal for range riding for conflict reduction is to monitor livestock-predator interactions and activity to minimize conflicts and improve range utilization and forage quality. This practice may include monitoring predator and prey activity and livestock health, optimizing forage use, deflecting predators, detecting livestock depredations and/or grouping/herding livestock.

Range riding conservation practices and enhancements

CPS 528	**Prescribed Grazing - implemented through range riding**
CPS 645	**Upland Wildlife Habitat Management - for wildlife cameras and other tools**
E382A	Incorporating wildlife friendly fencing for connectivity of wildlife food resources
E382B	Installing electric fence offsets and wire for cross-fencing to improve grazing management
E528A	Maintaining quantity and quality of forage for animal health and productivity
E528C	Incorporating wildlife refuge areas in contingency plans for wildlife
E528D	Grazing management for improving quantity and quality of food or cover and shelter for wildlife
E528N	Enhanced grazing management through monitoring
E528P	Implementing bale or swath grazing to increase organic matter and reduce nutrients in surface water
E528Q	Use of body condition scoring for livestock on a monthly basis to keep track of herd health
E528R	Management intensive rotational grazing
E528T	Grazing to reduce wildfire risks on forests
E645A	Reduction of attractants to human-subsidized predators in sensitive wildlife species habitat
E645D	Enhanced wildlife habitat management for upland landscapes

This tool may be applied within an adaptive management structure through observation, evaluation, and management. A range rider can observe livestock and carnivore movement through visual cues and game cameras, work with cowboys and livestock owners to identify best actions and manage the situation through applying additional predator deterrents, such as adjusting pasture rotation, or reporting depredation events (injuries or mortalities) to the appropriate wildlife management agency. Thus, range riders support whole and sustainable agricultural productivity and working lands.

Range riding differs in its application by region and by livestock operation due to several variables, including vegetation type, topography, predator population, livestock risk level (e.g. type of livestock) and road density and quality. Methods of transportation generally involve use of horses, although ATVs, vehicles and foot travel are also used. Variations in application include time of day riding, number of days/week or hours/day riding, use of consistent or variable schedule for riding and use of directional or aggregative herding.

Case Study: Range Riding in Southwestern Montana

Know your context: Southwest Montana contains some of the remaining intact and relatively undeveloped landscapes of the West where many species of iconic wildlife such as grizzly bears, wolves, moose, elk, trumpeter swans, Arctic grayling, and the Greater sage-grouse call home. One particular valley west of Yellowstone includes prime livestock grazing resources and a variety of Montane sagebrush steppe, wetlands and grasslands at 7,000 feet in elevation. The valley, comprising a patchwork of private and public lands, is only grazed from June-October.

Producers were noticing an increase in unconfirmed livestock losses at the end of the grazing season. During this same period, wolves and grizzlies were expanding into the valley from Yellowstone National Park. Landowners, producers, and partners participating in a place-based collaborative group in the valley convened to discuss a path forward. The group's wildlife coordinator and range rider explains, "Landowners and producers got together and determined that range riding was a good way to have more eyes on the landscape to monitor livestock and predator activity. Producers can't be out on the large rangelands every day due to other ranch and family responsibilities, so having the support of people who are specifically dedicated to range riding was really important."

Identify goals and objectives: The goals of this range rider program are to reduce the number of unconfirmed losses and depredations through monitoring predator activity and identifying risk factors to livestock that could increase the chance of a depredation event. This is achieved through the presence of range riders who are specifically dedicated to monitoring livestock and wildlife activity. The range riders will saddle a horse in the morning and each rider has time to ride through two of the seven to nine herds in a day. They look at cattle health and behavior, mineral availability, fencing, water conditions, presence of larkspur, carcasses, signs of depredation events, while also reporting anything of concern to producers and other area stakeholders to increase community safety and awareness. All the variables above can make livestock more susceptible to depredation events, so the range riders are working to identify issues that canbe corrected now to reduce future susceptibility to predators and depredation events.

Communicate for success: Communication is a critical component of the range rider job with the goal to be disseminators of information regarding wildlife and livestock conflicts. The range rider coordinator writes bi-weekly reports that include photos from game cameras and shares information regarding where there may be increased risk of depredation. For example, when images are captured of bears feeding on elk calves, sharing this information informs the community of increased potential risks of grizzlies to humans and livestock. These reports also fuel excitement about the wildlife and support stakeholder interest in wildlife and conservation projects.

Integrate emerging strategies and complementary technology: The use of game cameras supports the group's goals by helping range riders "keep a pulse" on the predator population and activity on the landscape. The range riders in this particular valley are looking to understand the landscape and how wildlife uses the landscape, including calving seasons for elk, deer and moose, migration corridors and how fencing impacts migration and movement. Range riders also employ digital mapping, including Avenza and onX, that mayincorporate important information including pasture boundaries, water sources, and landmark names.

Continue to assess risk, evaluate outcomes and adapt activities : Adapting to seasonal stressors is a critical part of a range rider's job. During times of drought when some toxic plants become more desirable to cattle, daily attention must be paid to the presence of poisonous plants. Due to the toxicity of larkspur, ingesting it is usually fatal and additional livestock carcasses on the landscape can attract large carnivores, increasing the risk of a depredation event. Range riders will also adapt the placement of cameras seasonally to match the movement of carnivores and their main prey base, elk, as they move to lower elevations in fall and vice-versa by spring and summer.

Carcass management

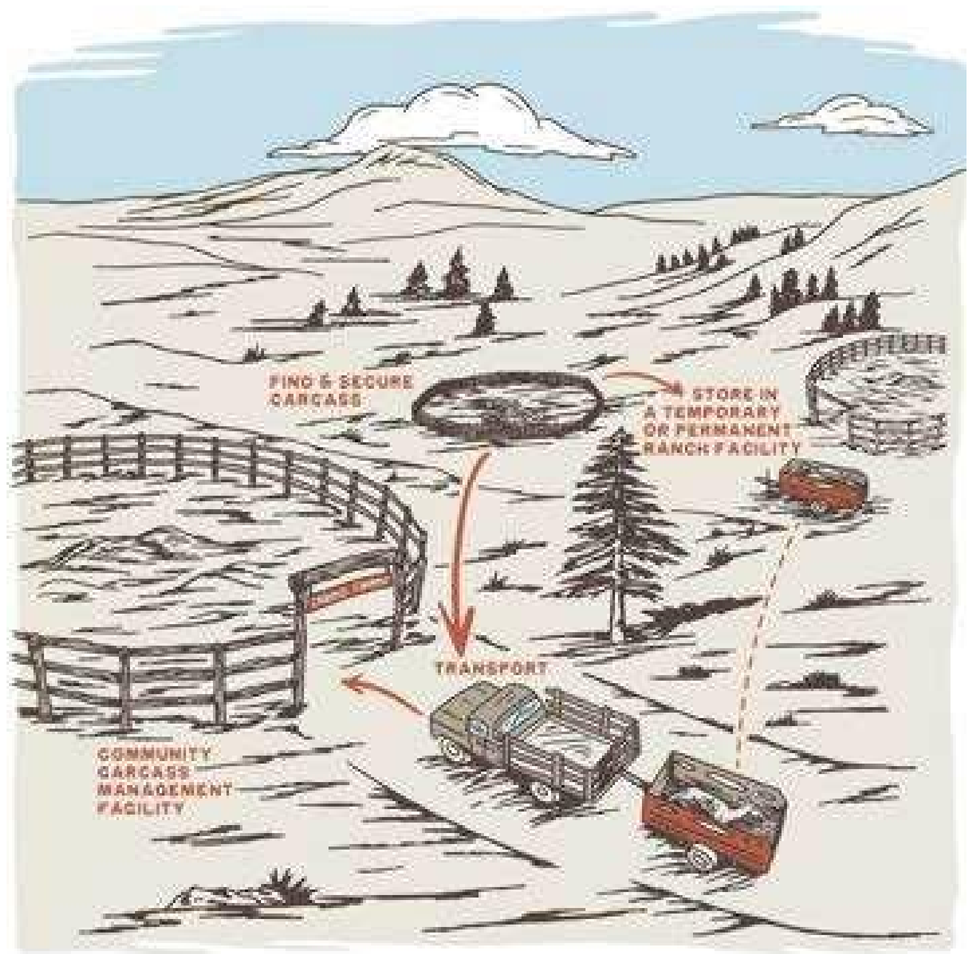

Figure 2. Carcass management

A main goal of carnivore-livestock conflict mitigation is reducing the availability of attractants on the landscape, in this case, animal carcasses and bone piles. Carcass management focuses on securing or removing carcasses and bone piles to reduce potential attractions on the landscape that can bring predators within close proximity to livestock, thereby increasing the potential for depredations and conflict. Securing and removing carcasses has also been shown to reduce raven densities, thereby benefiting sage-grouse populations whom they predate.

Carcass management may be split into four components: finding and securing the carcass, transportation, on-ranch mortality facility and community carcass management facility.

Finding and securing a carcass: This is the first component to any carcass management program; it involves identifying a carcass, securing it on-site with fencing, or transporting it to a more secure location. Deceased livestock in corrals or calving barns may be easier to identify and secure, but determining the location of deadstock in open range is more challenging and may be contingent on terrain roughness, extent of tree cover, proximity to roadways and frequency of livestock monitoring. These factors are also relevant to transporting the carcass to a more secure location, as areas unreachable by pickup-truck or heavy machinery may not be viable. In these situations, where a carcass may not be accessed, a temporary fladry fence can be placed around it, or a heavy tarpaulin bag with added enzymes may be used to expedite breakdown.

Temporary or permanent on-ranch facilities: This practice can be used during times of greater need for carcass removal (calving, for example). If heavy equipment is available, a dump trailer or other temporary structure can be used to hold carcasses prior to transporting to a community facility. The location of the dump trailer on the ranch must be considered carefully to avoid attracting large carnivores. Burying carcasses is not seen as a solution for securing and temporarily storing a carcass. Carcass composting can be accomplished on-ranch or through community scale facilities.

Transportation: Transportation, whether coordinated through a third-party group or enacted by a producer, is required to centralize carcasses in a facility. Often, the destination of the carcass in a secure site is a substantial distance from ranches. This requires either producer labor, time, and infrastructure to transport a carcass using a truck, or a community-run carcass pickup program whereby a dump trailer and driver are on-call to pick up carcasses.

Community carcass management facility: Community carcass management facilities most often take the form of a carcass composting site or an established county landfill or fenced trash transfer site that accept carcassess. Carcass composting sites, often run by a community group or a collaboration of county and state agencies, offer secure, enclosed locations to convert disposed carcasses into soil through the process of composting. County landfills that accept carcasses are a readily available medium to deposit carcasses, but fees can disincentivize use.

Carcass management practices and enhancements

CPS 316	**Animal Mortality Facility - including carcass management scenario**
CPS 382	**Fence - electrified fencing/fladry scenario**
E645A	Reduction of attractants to human-subsidized predators in sensitive wildlife species habitat
E645D	Enhanced wildlife habitat management for upland landscapes

Electric fencing

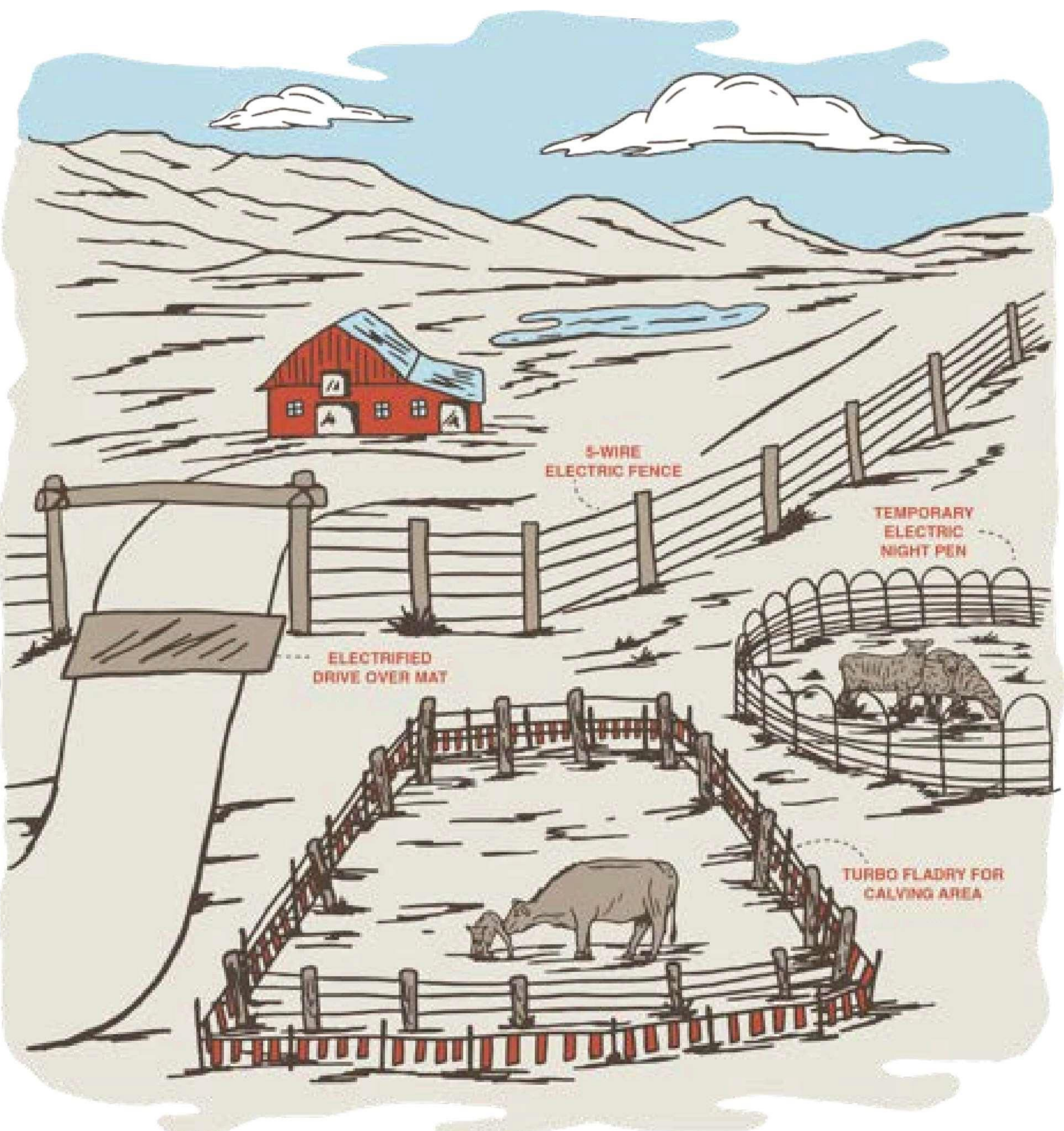

Figure 3. Electric fencing

As exemplified by carcass management, an important step in mitigating human-wildlife conflict is securing attractants. Electric fencing excludes carnivores and contains livestock. Electric fencing is a common tool for effective conflict mitigation between wildlife and livestock, yet these practices come with challenges, limitations and best practices for their implementation to be successful. This success is dependent on fencing for context-specific purposes. Within this section, we share information on four of the most commonly used forms of wildlife fencing: mesh wire fence for night pens, turbo fladry, 5 and 4-wire fences, and electric drive-over mats.

Electric fencing practices and enhancements

CPS 382	**Fence - electrified fencing/fladry scenario**
CPS 649	**Structures for Wildlife - for electric mats**
E382A	Incorporating wildlife friendly fencing for connectivity of wildlife food resources
E382B	Installing electric fence offsets and wire for cross-fencing to improve grazing management
E528R	Management intensive rotational grazing
E528T	Grazing to reduce wildfire risks on forests
E645A	Reduction of attractants to human-subsidized predators in sensitive wildlife species habitat

Night penning: Livestock can be grouped together at night using permanent or temporary fencing. This grouping serves to keep livestock from separating too much throughout the night and becoming easy targets for carnivores. Electrified net fencing is commonly used for this practice, as it is easy to install, portable and connects in series to surround livestock. The enclosure should be small enough to prevent excessive movement during the night, but not so small to cause lambs to be laid on. The pens should be big enough for sheep to be able to lay down comfortably. In conditions of heavy rain or mud, it is recommended to move the pen more frequently to mitigate spread of disease. Night penning is made more effective by use in conjunction with electrified fencing, fladry, or guard dogs. These pens are also typically more successful when they are close to humans or human structures.

Case Study: Electrified Night Penning in Oregon

Know your context: A sheep producer has experienced conflicts with gray wolves on summer allotments while grazing a band of ewes with lambs. The allotments are on USFS and BLM lands. Management is conducted by a full-time sheepherder and livestock guardian dogs. The permittee runs a band of sheep (ewes and lambs, approx. 1,000 head) over the summer after snow has melted and the allotments are accessible, with predation events historically occurring at night. The producer decided to use electrified night penning as the best-fit tool to enclose sheep in hopes of preventing depredations when they are most vulnerable - at night.

Identify goals and objectives: Prior to the 2014 arrival of wolves on the landscape, the goal was keeping sheep close to camp overnight. Once wolves became present, the goal became preventing depredations at night and night penning was implemented as the best-fit practice. Other stewardship benefits include improved range management, as the night pen can be set up in a specific area to be used as a targeted grazing project to manage undesirable vegetation and remove dead forage. After grazing, the producer broadcasts native grass seed on the area and the site in attempts to return the site to its original state.

Communicate for success: In 2014, the local USFS district ranger alerted the producer that Oregon Department of Fish and Wildlife (ODFW) would purchase 5 rolls of electric fence to support the producer in night penning sheep for wolf-sheep conflict reduction. ODFW has purchased three rounds of fence to date. This producer's operation has been used by USFS as an example of effective night penning for other producers interested in incorporating night penning into their management plans, and federal and state agencies have been universally supportive of the management practice.

Integrate emerging strategies and technology: The producer believes that the use of livestock guardian dogs is complementary to the night penning and often one of the dogs will spend the night with the sheep while the others stay on the outside to maintain a perimeter presence.

Continue to assess risk, evaluate outcomes, and adapt activities: Daytime depredation incidents increased after 4-5 years of night penning as predators changed their activity patterns in response to this management practice, but the producer finds it easier to haze wolves during daylight hours. The producer has experienced zero nighttime sheep depredations since incorporating electrified night penning as a management tool. Penning has also been used successfully in the wintertime to keep sheep safe during periods of increased snow.

5 and 4-wire fences: This permanent fence type may be used to exclude predators from the ranch or farmstead or secure attractants including grain or calving pens. Fence posts should be above 40" out of the ground with wires attached every 6 to 8 inches. Permanent electric fences are most effective when they are constructed using 12-14-gauge wire. To protect against wolves and coyotes, the fence should be charged to at least 5,000 volts and the bottom wire should not be placed higher than 6" above the ground, as canines are known to dig under wire, if possible, to reach prey. For grizzlies, the bottom wire should be about 8-12 inches above the ground and the top wire should be located at a height of between 36 and 42 inches. Wires should be spaced around 8 inches apart. The fence should be charged to 6,000 volts or more and requires an energizer of at least 0.7 joules to deliver adequate power over the distance covered. Because these fences must stay charged to work successfully, it is important that they are checked at least once a day to ensure that it is not disrupted by vegetation or landscape.

Electric drive-over mats: Electric mats reduce the need for individuals to open and close gates when moving between pastures, calving pens, or the home ranch. The mats provide an opening, but not one that is passable by predators. They are most effective in preventing grizzly bear conflicts when charged alongside a 5-wire electric fence. The bottom wire should be approximately 8 inches off the ground to avoid bears crawling under. The electric fence should have a minimum power rating of at least 1 joule, but a higher rating is encouraged. The mats should be charged to provide a strong enough shock to deter the bear from passing. Multiple design options have proven effective. Both the Pitman Machining mat that consists of a rubber pad and a 2" x 2" metal grid held in place by a ring of rubber matting, as well as the BS Fabrication plastic pad with a layer of galvanized steel on top, proved to be effective in keeping bears out of the properties.

Turbo fladry: Turbo Fladry consists of a row of colored nylon, or polyester flags (typically red) attached to electric poly-wire surrounding a specific livestock pasture. The movement of flags or streamers from a fenced area creates a visual disturbance that makes predators, particularly wolves and coyotes, hesitant to approach. Though, this practice is not effective against bears. It can be rapidly and easily installed to complement many types of fence, which makes it very useful for many operations. Turbo fladry itself should not be used as a permanent tool. It has been shown to deter wolves for up to 60 days. Fladry should be placed close to 18 inches apart on temporary or permanent fencing. It should hang on a fence strand that is no higher than 28 inches above the ground and should be placed to avoid surrounding vegetation. Fladry is less practical when used in terrain that has vegetation or other terrain obstacles that may disrupt movement of the material. This tool does require consistent maintenance to be effective.

Project Planning: The Planning Framework for Predation Risk Management

Predation risk management practices will be most effective when selected for application through a holistic ranch management and conservation framework considering landscape characteristics and rangeland health, wildlife habitat limitations and improvement potential, and operation-specific risk evaluation and ongoing monitoring. The Planning Framework for Predation Risk Management paired with the Risk Assessment Framework provides guidance for conservation planners to work alongside livestock producers to determine the best tool or tools to fit the specific context and need. Used together, these frameworks are intended to operationalize best management practices from research and livestock producer knowledge for effective place-based conservation delivery.

Step 1: Know your context

The effectiveness of predation risk management practices differs between locations and through time; what works in one location doesn't necessarily work in a seemingly similar situation. Characteristics that may affect the ability of practices to reduce conflict include terrain characteristics (forest cover, steepness, and accessibility), in addition to wildlife type and movement patterns. Local knowledge and situational awareness of the contexts that affect conflict prevention practices in reducing conflict is essential towards their application and adaptive management. It is important for conservation planners and livestock producers who have intimate knowledge of the local context affecting patterns of conflict and where and how to apply conflict prevention practices.

The Risk Assessment Framework is a way to evaluate predation risk through a land-use stratification lens: some areas sustain more intensive human/livestock use (e.g. homesteads and calving or weaning pastures); some areas are shared between livestock and predators (e.g. large pastures/allotments); and, other areas sustain more intensive predator activity, time and space dependent (e.g. den locations, travel corridors, and rendezvous sites). Stratification of the landscape can inform decisions about where to implement predation risk management practices. This framework provides logical steps for conservation planners and producers to identify areas of risk on the property and helps stratify the landscape into human/livestock use and areas of intensive predator activity. It is recommended that planners and producers move through this framework during and after site evaluations to inform the context-specific and successful implementation of predation risk management practices.

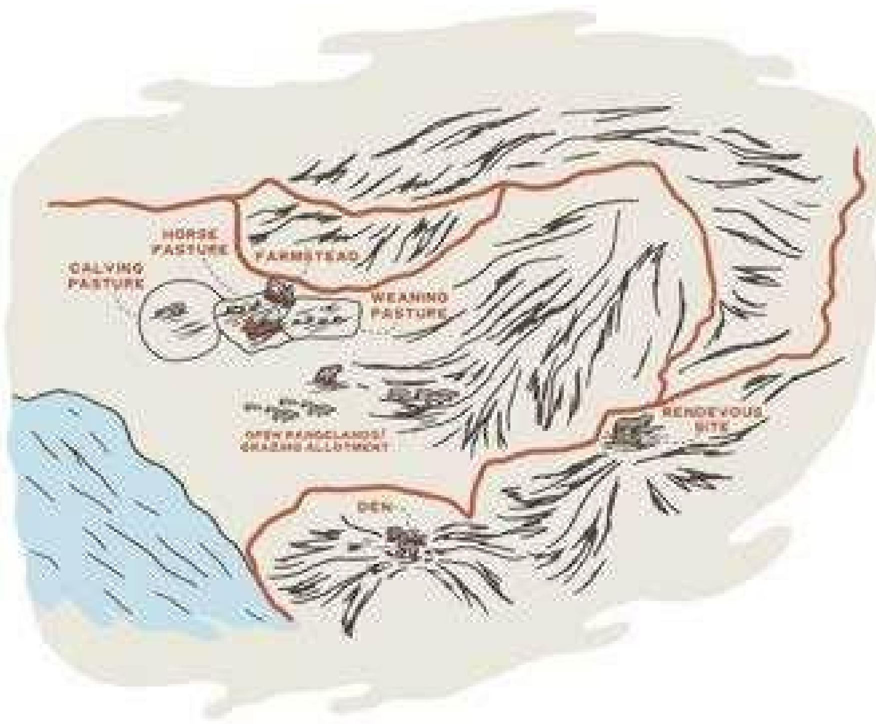

Figure 4. Landscape stratification through risk assessment

The Risk Assessment Framework

1. SPECIES: Type and population density of predators and type and age class of livestock alter the level of risk, as does the abundance and diversity of non-livestock prey.

2. PLACE: Each site or region has a unique set of abiotic and biotic conditions influencing predation risk (e.g., topography, canopy cover/density, water sources, forage availability, climate).

3. TIME: Conflict or predation risk happens in a temporal setting and changes over time based on habitat use and livestock/grazing management, based on annual life cycles of wildlife and annual production cycles of livestock or other agriculture crops.

4. DISTURBANCE: Events whose effects may strongly influence wildlife populations, behavior, and ecosystem dynamics and therefore impact predation risk (e.g., snow, drought, fire, recreation, lethal control).

5. LANDSCAPE/LAND USE: The size, shape, and spatial relationships of habitat patches and livestock pastures on a ranch or in a region affect ecosystem function, community dynamics and predation risk, along with the ability to implement certain strategies (e.g. road access).

These five factors were adapted from Dale et al. 2000. Ecological Principles and Guidelines for Managing the Use of Land, a report of the Ecological Society of America Committee on Land Use.

Case Study: Applying the Risk Assessment Framework

Figure 5: Map indicating allotment location, summer concentrations of black bears, and human conflict areas.

Species: A sheep producer is experiencing chronic conflicts with black bears on summer allotments, reporting nearly 12% annual loss to black bear predation.

Place/Time: The allotments are on US Forest Service lands, in a roadless area which makes access challenging. Most management is conducted on horseback with only some areas accessible by ATV. The permittees run two bands of sheep (approx. 1,000 head per band) over the summer after snow has melted and the allotments are accessible, with predation events occurring through the summer.

Disturbance: Within this assessment, the NRCS biologist and livestock producer did not analyze potential for increasing depredation given disturbances such as drought, fire, hunting recreation, or lethal control.

Landscape/Land use: The producer worked with an NRCS biologist to map high-conflict areas using activity mapping of bear activity (Figure 5), the bear management plan for bears in the unit and producer-identified conflict-zones indicating hot-spots. Combining these sources of information created a better understanding of the area to apply potential treatments (Figure 7).

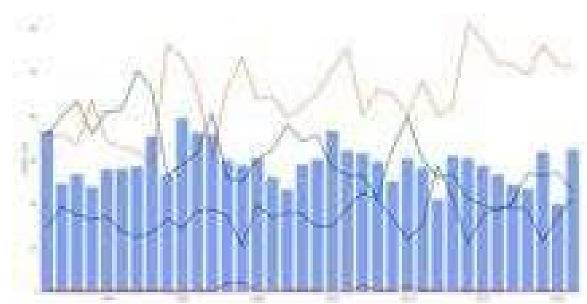

Figure 6: Rangeland Analysis Platform data indicating increasing tree cover on allotments (30 to 50%) and decline in perennial forb and grass cover (40% to 25%)

The NRCS biologist used ecological site descriptions, as well as the Rangeland Analysis Platform to assess land cover change over time. On the allotments, vegetation trends over the past 25 years indicate tree cover has increased from -30% to -50% and perennial forb and grass cover has decreased from -40% to -25%, while shrub cover had only increased slightly. Bare ground and annual forb/grass cover had not changed much and remained very low <5% cover (Figure 6 - Rangeland Analysis Platform data).

Conservation action: Combining these site and vegetation analyses as an initial assessment of predation risk, the landowner applied for and was funded for Conservation Practice Standard 645 - Upland Wildlife Habitat Management to monitor signs of elk calving/production and black bear conflict/kill. Based on both physical signs as well as game camera images, this information helped to determine potential management activities - such as possible adjustments to grazing timing and rotation, as well as brush management or other habitat modifications to improve visibility and address the increases in tree cover.

In year 1 (2023), the producer worked with the NRCS biologist, a state management agency District Wildlife Manager, and a USDA-Wildlife Services field biologist to monitor for signs of wildlife using game cameras to detect black bear and elk, especially at high-risk areas like sheep camps and watering locations. Monitoring data from 2023 is being used to plan and adapt the operation's grazing rotation, determine strategic areas to use fencing, fladry or other predator deterrents and to identify areas for habitat/land treatments such as brush management.

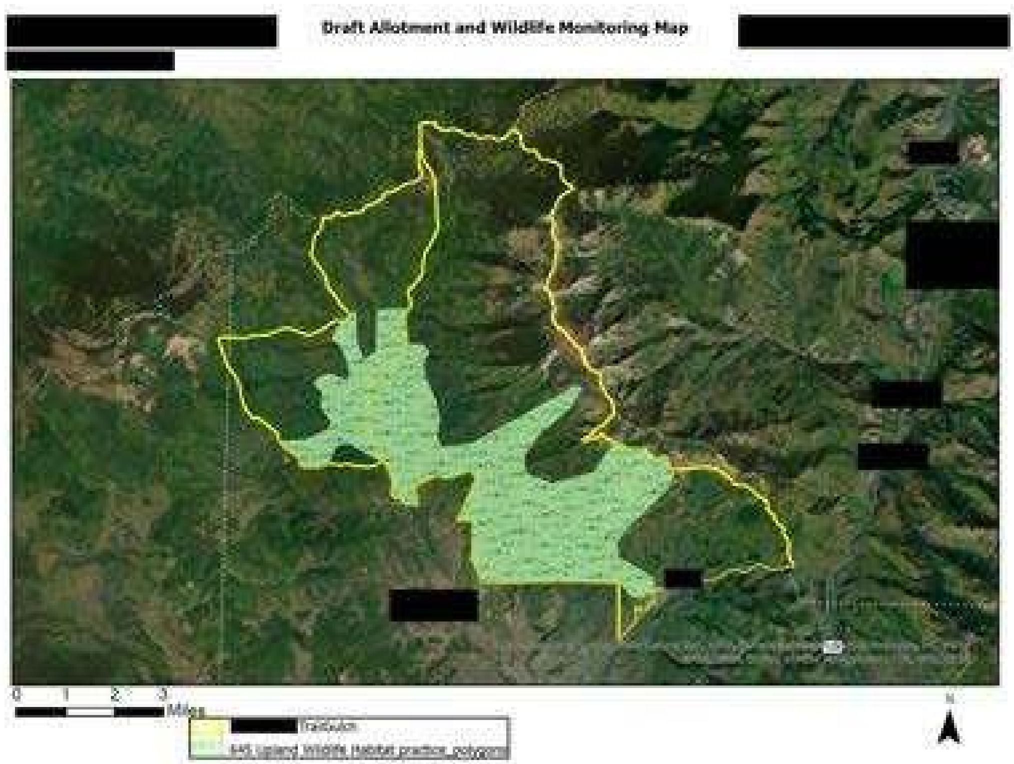

Figure 7: Map identifying the area of upland wildlife habitat management implementation, created from producer-identified conflict hots-spots.

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1. SPECIES

Type and population density of predators and type and age class of livestock alter the level of risk, as does the abundance and diversity of non-livestock prey.

Evaluate the species, type, age class and population density of predators and type and age class of livestock. This information affects the level of risk, as does the abundance and diversity of prey. Determine predator(s) of concern and the location and availability of their natural prey base: Grizzlies, wolves, black bears, cougars, and coyotes each require unique activities/response (please see the predator ecology section for additional information). Once the predator of concern is identified, it is important to be familiar with specific laws/regulations surrounding management of predator species including lethal control, hazing and harassment. Assess predator behavior: nocturnal/diurnal, mode of predation, availability of wild prey, use of landscape, history of depredation events, pack size/predator density, location of den and rendezvous sites, timing of reproduction and changes to nutritional requirements.

Questions to consider

- What large predators are present or likely to move through the area - grizzly bears, wolves, or other species?
- What is the age and class of livestock?
- What is the availability of native prey based on annual ungulate recruitment?
- What type and class of livestock are being managed?

Practice specific considerations

Range riding: Consider the species when determining where and how to apply the range riding practices. Many range riding management practices can reduce risks to multiple types of carnivores, while also maintaining herd health, adapted grazing rotations and noxious weed avoidance, though human safety should be a significant consideration with the presence of grizzly bears.

Carcass management: Special consideration should be given to ensuring human safety while securing carcasses with the presence of grizzly bears.

Fencing: Consider the species when choosing an appropriate fence. Practices such as turbo-fladry tap into neophobic tendencies of canids, though not all flag spacing that works for wolves also works for coyotes. Turbo-fladry will be less effective for deterring mountain lions or grizzly bears, though the electric poly-wire may add a level of deterrence.

2. PLACE

Each site or region has a unique set of abiotic and biotic conditions influencing predation risk including topography, canopy cover/density, water sources, forage availability, climate, terrain - rough/rolling/plain, visibility - high/moderate/low, vegetation community type - timber, shrub, riparian/willow, grassland/meadow. These characteristics can affect the accessibility of different locations on an operation, with implications for successfully implementing range riding or carcass management, or define whether building different fence types are feasible.

Questions to consider

- Is the terrain rough, rolling, or plain; is the topography steep, moderate or level?
- Is visibility high, moderate or low? Due to topography, vegetation community type, or both?
- What is the availability of water for livestock? For predators?
- Does the landscape support changes in grazing strategy or rotation patterns?

Practice specific considerations

Range riding: The landscape should be evaluated for travel permeability: Road/trail density, road/trail quality (changes seasonally), visibility, restrictions; then determine best modes of transportation. Are areas only accessible on foot, horseback, pickup, dirt bike/ATV?

Carcass management: Consider factors that make it challenging to transport carcasses on-site including pasture proximity to roadways, terrain roughness and forage cover. If considering an on-site animal mortality facility, consider proximity to structures and ease of access. Consider what are the existing carcass management practices, if any, currently exist on the landscape? (Landfill, composting site, etc.)

Fencing: Consider vegetation height that could short electric fencing. Consider topography changes that could create challenges in constructing and maintaining a fence including:

- Terrain - rough/rolling/plains
- Visibility - high/moderate/low
- Vegetation community type - timber, shrub, riparian/willow, grassland/meadow

3. TIME

Conflict or predation risk happens in a temporal setting and changes over time based on habitat use and livestock/grazing management, such as annual life cycles of wildlife and annual production cycles of livestock or other agriculture crops.

Changes may also occur in periodicity seasonally and at different times of day and are often variable and hard to predict. Consider the annual life cycle and changing nutritional needs of wildlife, the production cycle of livestock and how the overlap of those cycles contributes to increased risk of conflict.

Human safety is a priority and should always be considered during the planning process. Predators are generally less active during the day making it safer for range riding or securing and transporting carcasses, particularly in grizzly country. Visibility of bird activity and evaluation of livestock health is easiest during daylight hours, while many depredations may occur at night. Consider the time required to locate and assess livestock. Conflict or predation risk happens in a temporal setting and changes over time based on habitat use (including annual life-cycle stage) and livestock/grazing management (type oflivestock).

Questions to consider

- Does conflict occur year-round, seasonally, or is it variable?
- Does conflict happen primarily during the day, night, dawn, dusk, or is it variable

Practice specific considerations

Range riding: Consider the frequency of range riding, time of day/night, and time required to adequately monitor livestock. Consider the seasons of need: is a range rider appropriate year-round? Or only needed seasonally?

Carcass management: Match frequency of carcass removal with times of greatest predator food needs and carcass availability? When do you need the tool? Year round? Seasonally? During which activity (e.g., calving, summer range, etc.)? Collection site: Onsite, offsite, single site, multiple sites.

Fencing: When do you need to incorporate a fencing scenario? Year round vs. seasonal; 24 hours vs. nighttime vs. daytime; during calving? Identify the greatest time of need.

4. DISTURBANCE

Evaluate events whose effects may strongly influence wildlife populations, behavior and ecosystem dynamics, thereby impacting predation risk. Consider heavy, moderate, or light seasonal snowpack; type and density of recreation use may habituate predators to human presence and may also provide additional anthropogenic attractants on the landscape; the presence of gut piles during hunting season are powerful attractants for predators; resource limitations such as drought or wildfire change prey behavior and availability; and lethal control (if applicable) through hunting and/or agency management.

Questions to consider

- Is the seasonal snowpack heavy, moderate or light?
- What anthropogenic attractants exist on the landscape?
- What is the recreational use- is it heavy, moderate or light, and does it involve hunting, or "passive" recreation?

Practice specific considerations

Range riding: Consider how disturbances change the temporal and spatial distribution of livestock on the landscape. Consider how disturbances affect livestock health. Consider where noxious weed may exist to inform herd management (noxious weeds can result in deadstock that may act as carnivore attractants).

Carcass management: Consider the severity of weather events, first preparing to mitigate losses, but when inevitable losses occur, plan for increases in both wildlife and livestock carcasses with severe events such as cold, drought, or storms.

Fencing: *No additional considerations.*

5. LANDSCAPE/LAND USE

The size, shape and spatial relationships of habitat patches and livestock pastures on a ranch or in a region affect ecosystem function, community dynamics and predation risk, along with the ability to implement certain strategies (e.g. road access).

Evaluate the landscape: accessibility, acreage, ownership/management, livestock and predator use. Elevation, climate, topography, vegetation type and density, visibility, size and number of grazing allotments/pastures, public/private land all help determine the capacity needed. Evaluate livestock use of the landscape including water access, daily behavior, bunching and foraging. Evaluate travel permeability including road density and quality (which changes seasonally), visibility and travel restrictions. Given those evaluations, determine best modes of transportation: on foot, horseback, pickup, dirt bike/ATV. Understand the seasonality oflivestock grazing and interactions with wildlife. Availability of wild prey, timing of calving/lambing or turn-out, recreation, hunting, historical depredation and seasonality patterns of conflict. The size, shape and spatial relationships of habitat patches and livestock pastures on a ranch or in a region affect ecosystem function, community dynamics and predation risk, along with the ability to implement certain strategies.

Questions to consider

- Is the landscape accessible? By foot, vehicle, ATV, or horseback?
- What is the acreage? (1-500; 501-1000; 1001-5000; 5000+)
- How is this acreage stratified into human occupied/intensive use, shared and predator-occupied?
- What is the ownership/management pattern? (federal/state/private)
- What is the established management infrastructure? (Water, fence, handling facilities)

Practice specific considerations

Range riding: *No additional considerations.*

Carcass management: Consider whether you are engaging enough operations to cover the affected target geography. Consider whether wildlife carcasses (hunter drop off, motor vehicle collisions) should be included within the carcass disposal site. If constructing a new site, learn the environmental regulatory issues and/or bureaucratic limitations early in the process.

Fencing: Consider the practicality of fence type by ownership/management pattern (federal/state/private). Consider whether permanent vs. temporary/portable or new build vs. existing fencing retrofit. Consider the availability of water and whether it needs to be enclosed within the fence.

Step 2: Identify goals and objectives

Determining the goals appropriate for the operation, alongside the producer, that will guide the type and intensity of predation risk management practices and activities. These goals should be made in consideration of the social context of the community, as well as biotic and abiotic factors outlined in the risk assessment framework.

While the outcome of reduced conflicts amongst wildlife and livestock may remain consistent, the goals defining the context-specific use of predation risk management practices vary widely. They may include protecting livestock in a landscape where large predators are well established; maintaining or improving resource condition of shared, grazed landscapes; and/or maintaining a wildlife travel corridor and landscape permeability as predator populations expand and increase their range.

Depending on context, these goals may be established with an individual or shared amongst a community. For community scale projects, it's important to pay special attention to understanding the community dynamics, identifying community leaders and recognizing individuals with leadership qualities who can unite people. Leadership and local expertise can manifest in various ways.

Practice specific considerations

Range riding: Range riding can have a wide range of applications, with the primary application being reducing the risk of interaction between livestock and predatory wildlife, thereby reducing livestock death, injury and stress-induced production losses (i.e., shrink, reduced breed-up, illness) and is best applied through an adaptive management structure of observation, evaluation and management. As a result, it is important to set goals for each stage of this adaptive management process to guide when and where a range rider can observe both livestock and carnivore movement through visual cues and game cameras, work with cowboys and livestock owners to identify best-fit actions, and set expectations for management through applying additional predator deterrents, adjusted pasture rotation, or reporting depredation events (injuries or mortalities) to the appropriate wildlife management agency.

Carcass management: Along with the producer and partners, evaluate which of the four aspects of carcass management may be implemented or expanded on the operation or landscape including: securing the carcass, temporary or permanent on-ranch facilities, transportation, or community carcass management facility. Set goals for implementation for one or multiple aspects of carnivore management to meet producer and partner needs.

Fencing: Applying the land-stratification framework, determine whether the producer is looking to exclude carnivores from human and livestock dominated areas (i.e., 5 and 4-wire fencing, temporary turbo-fladry), enclose livestock in an open range settings (i.e., temporary mesh wire night pens for sheep, or permanent 5-wire electrified night pen) or increase permeability of farmstead fencing for foot and vehicle traffic (i.e., electric drive-over mat).

Step 3: Context specific application

To effectively prevent carnivore learning and association oflivestock as a food-source and support rangeland stewardship, range riding, carcass management and electric fencing require context-specific application and adaptive management. Identifying best-fit tools for each situation requires an understanding of: 1. Where risk for carnivore-livestock conflicts exists on the landscape; 2. Stratification of human occupied areas, shared predator and livestock areas, and predator occupied areas, 3. Biotic and abiotic characteristics that affect whether a tool may be successfully implemented; and 4. Social conditions or support for certain tools **within** a community. The Risk Assessment Framework sets the stage for this understanding and will help define the feasibility of implementation for each practice. Further, identifying and setting goals with the livestock producer will help determine the type and intensity of action to reduce risk.

Practice specific considerations

Range riding: Within the land stratification framework, range riding may be most useful within shared landscapes, where livestock and carnivore range overlap in open-range contexts, including large pasture systems and grazing allotments.

Carcass management: Carcass management is a highly adaptable tool relevant to a wide variety of rangeland contexts. While this is easiest to apply near the homestead, where it is not difficult to secure and transport carcasses, it is just as relevant in shared predator and livestock open-range contexts. In these open range contexts, proximity to a road and terrain roughness usually dictate whether a carcass may be transported, or whether it may be managed on-site by other means.

Fencing: While each fence type has different applications, each is purposed to exclude carnivores from a specific area of concern. This makes fencing particularly useful in areas of intensive human/livestock use, enclosing homesteads or calving and weaning pastures. While some fence types, including electrified woven wire night-pens or turbo-fladry, may be helpful to temporarily exclude carnivores from targeted areas in open-rangeland contexts, these practices are not always applicable at extensive scales, as materials and monitoring costs precipitously increase and efficacy decreases. To be successful and effective, the fence must be built according to best practices. Information on what makes effective temporary and permanent fences is widely available and for successful implementation, those practices must be carefully followed.

Step 4. Communicate for success

Partnerships play a vital role in addressing wildlife conflicts, involving various stakeholders at multiple levels. Public acceptance and stakeholder involvement are essential for uniting rural communities. In this endeavor, nonprofits, state and federal agencies and universities serve as crucial technical and funding partners, contributing to the success of wildlife conflict management initiatives. Establishing and nurturing relationships and trust among private operators are paramount, as the human aspect presents one of the most significant challenges in addressing wildlife conflicts. Building trust and fostering ongoing communication between landowners, neighbors, ranch employees, agency personnel, nonprofit staff and funders are essential components of successful conflict risk management efforts.

Relationships and trust between private operators are critical, and the human aspect is the most challenging part of wildlife conflict. Devoting effort to building and nurturing relationships can yield valuable insights, expertise, and assets when it comes to mitigating conflicts with carnivorous animals. This endeavor can harness the power of scientific expertise, a wide range of skills (including those oflocal specialists, hunters, and damage assessors), as well as financial resources for optimal effectiveness. Such a multifaceted collaboration may also align with the principles and priorities of both local communities and groups who share common interests.

At the local level, place-based collaborative groups play a crucial role in promoting conflict prevention practices within communities. These groups engage with landowners through workshops and one-on-one meetings and support mutually learning about conflict prevention techniques. They also offer technical assistance and cost-sharing programs to help alleviate the financial burden associated with implementing and maintaining these practices. Furthermore, place-based collaborative groups provide a structured platform for building trust and cooperation with state and federal agencies, as well as nonprofit organizations, which can offer additional technical and financial support for conflict prevention efforts.

Practice specific considerations

Range riding: Whether on a single or multiple operations, range riding can build coordination, communication and trust between producers and agencies. Range riders often coordinate amongst agencies, producers, and neighbors to share information, including general carnivore location, depredations and information relevant to support landscape health and stewardship. In situations where trust has broken down amongst agencies and producers, a range rider can restart dialogue and reduce barriers to communication.

Carcass management: In the case of carcass drop off locations, producers often worry about the appearance of negligent husbandry if they are using the site frequently. Anonymous drop offs can be an important way to increase producer use of the site, as maintaining trust and anonymity of producers is critical for success.

Fencing: Neighbors with similar objectives and resource concerns can be addressed together. For example, a grizzly fence with a common boundary may take in two calving lots and two headquarters to address a high concentration of attractants.

Case Study: Planning Framework for Predation Risk Management-Collaboration and Implementation in Northwestern Montana

Know your context: Within Northwestern Montana, a place-based landowner led collaborative group has coordinated efforts to conserve and enhance the natural resources and rural way oflife within their project area. Anywhere from 10-12 wolf packs and 50-60 grizzly bears frequent the valley, overlapping vibrant ranching lands. In coordination with local producers the now executive director spent 1.5 years mapping out land use through documenting the location of calving locations, boneyards, beehives, and riparian areas. The executive director acquired their own data as well as external GPS data from the USFWS showing bear movement to create risk maps. After mapping, they found that close to 70% of all conflicts were in 6% of the huge project area. "You find these really strong patterns through this type of modeling," said the executive director. Another tool employed by the community are winter wolf surveys and pre-pasture turnout surveys where range riders evaluate the landscape prior to livestock turnout looking for dens and rendezvous sites to evaluate landscape risk.

Goals: In the early 2000's, the collaborative group spent a year working through problem identification related to grizzly bear recolonization and conflicts through landowner and livestock producer listening sessions. From these conversations they identified three primary goals: 1. Protect human safety; 2. Maintain vibrant livelihoods; and 3. Minimize economic impacts to producers. Carcass management, electrified fencing and garbage management were three practices that were identified early on with an eye toward making the landscape safe for people and bears. Social capital and conflict reduction infrastructure, including fencing specced for multiple carnivore types, developed through the process of meeting grizzly bear related goals set the stage for conflict reduction work with gray wolves as their populations expanded within the valley.

Context specific application: Maps developed through the landscape assessment were an important tool to prioritize placement of conflict prevention tools and support visual learning material for landowners to see where bears were traveling and where conflicts were occurring in relation to their operation. This information helped prioritize resources for predation risk management at landscape scale.

Range riding: The collaborative group has organized a range rider program since 2007, one of the longest standing programs in the country. Managers have targeted range riders where there is current wolf activity, denning locations and rendezvous sites that coincide with livestock in open rangelands settings. Though, the program has shifted away from intensive wolf monitoring to livestock herd health.

Carcass management: The collaborative group originally offered carcass pickup solely during calving season, but producers began requesting assistance with carcass removal during other seasons as well, so the group responded, extending it to a year-round practice. Producers take a lot of pride in their animal husbandry skills, so community-level carcass removal programs require a lot of trust for producers to feel comfortable participating. Simple solutions, such as removing ear tags from carcasses and adding a few rails on a pickup truck or dump trailer to prevent viewing the number of carcasses being removed from an operation can really improve confidentiality when hauling carcasses.

Fencing: The collaborative group has supported extensive fencing projects throughout the valley to secure attractants surrounding farmsteads. Maintaining electric fences does require additional capacity. Weeds and maintenance can be an issue. Grounding systems are important to manage and the manager shares that it's important that landowners have a stake in fence maintenance. If properly maintained, permanent fencing lasts 15-20 years in the valley. Within the valley, due to elk movement, it is important to consider adapting fences to lay over to prevent elk damage and to accommodate elk movement with proper line post spacing (40 to 60-foot line post spacing).

Communicate for success: The group's successes have been built on the strong relationships between livestock producers and agencies delivering support for conflict reduction, including NRCS, Montana Fish Wildlife and Parks, and the USFWS, through consistent dialogue and shared goals. One of the great successes of the group is the partnership with NRCS, which empowers outreach to landowners that connect them with resources, specifically cultivating interest in EQIP practices and even completing the initial paperwork and producer sign-ups.

Integrate emerging strategies and technology: A Montana State Conservation Innovation Grant through NRCS supported the innovation of electrified drive-over mats. These mats were developed to replace time-intensive gates within 5-wire fences that had to be open and closed each time the landowner entered or exited the farmstead. These electrified mats are quite effective against grizzly bears, deterring them from walking through any opening in the fence. While this has not been tested for use in preventing wolves from crossing a threshold, it is very likely that it would be successful.

Continue to assess risk, evaluate outcomes, and adapt activities: The executive director shares that models and maps are important to keep updated, but they can be inaccurate. Common sense and local knowledge from landowners and livestock producers should be prioritized above the use of models and maps to inform the continual application and adaptive management of tools to remain effective and supported by the community.

Step 5. Integrate emerging strategies and technology

Available and emerging management practices and technologies can support a producer in implementing non-lethal predation risk management practices. While some technologies or management practices may be outside of NRCS payment scenarios, partnerships and coordination with other agencies, nonprofits and place-based groups can build the capacity necessary for the integration of novel tools and management strategies within holistic frameworks to reduce predation risk.

Examples of incorporating technology to support producer-implemented and coordinated activities include using tracking technology on cattle to increase the efficiency of locating and checking livestock health and behavior, electrified drive over mats at ranch homestead entryways to prevent grizzly bears from entering, the use of game cameras to evaluate the effectiveness of fencing and incorporating artificial intelligence and cellular technology into game cameras to automate remote detection of predator species.

Practice specific considerations

Range riding: Emerging technologies and management practices provide ample opportunities for combination with range riding. Technology including virtual fencing, drone use for livestock and carnivore monitoring, game cameras with artificial intelligence and communication capabilities and mechanized mineral bins to clump livestock may work to improve the efficacy of this practice.

Carcass management: Planner and producers assess novel logistics for collecting or placing carcasses. For example, a conflict reduction expert and producers are innovating the practice in one community by adapting a storage container with a closing lid that may be placed in remote locations to deposit carcasses prior to being transported to a centralized facility.

Fencing: Enclosing livestock guardian dogs within fences alongside stock, radio-activated guard (RAG) boxes that set off sounds and lights when VHF collared wolves approach, as well as fox lights may all increase the effectiveness of permanent and temporary fencing.

Step 6. Continue to assess risk, evaluate outcomes, and adapt activities

Conflict prevention practices require time, expertise, and resources to implement and adaptively manage. Technical and financial assistance is often necessary to assist landowners with successful predation risk management. Coordinated efforts among NRCS, state wildlife management agencies, federal agencies and nonprofits are important for delivering and supporting the effectiveness of range riding, carcass management and fencing. To curb carnivore learning, it is important to continually change and adapt practices to prevent habituation, depredation, and transference of this knowledge to packs and offspring. This requires continued monitoring, maintenance, and adaptive management.

Monitoring: In relation to project goals identified during the *Identify your goals* stage of the planning framework, monitor whether the practice is making steps towards achieving developed goals. This monitoring can be achieved through collecting and analyzing data to measure the effectiveness of each implemented practice, and can also include qualitative assessments of user experience, challenges, and successes.

Maintenance: Established physical infrastructure for fencing or carcass management programs require continued maintenance to support effectiveness. While maintenance for this infrastructure varies in periodicity and intensity, it is important to clearly outline the party or parties responsible for maintaining the infrastructure. Without this regular maintenance, practices may provide decreased effectiveness as fences and other infrastructure blow down, short out through vegetation growth or fall into disrepair.

Adaptive management: To support predator risk management, planners and producers should consider adapting how, when and where practices are implemented, as well as goals should new disturbances occur. After developing an understanding of whether a practice or practices are or are not making progress towards identified goals, the planner and producer should strive to adapt their management plans and practices to meet any shortcomings. This may include changing the intensity and frequency of range riding, changing the timing and location of placing turbo fladry, or streamlining barriers within delivery of a carcass management program. Further, changing range conditions or added disturbances may necessitate shifting or adding new goals to address. This may necessitate further shifting of how, when and where practices are implemented for increased effectiveness.

Monitoring, maintenance, and adaptive management are essential, ongoing and iterative parts of the project. It will inform the value of ongoing participation by internal partners, determine if the strategy is working as intended, indicate areas for improvement and how the benefits weigh against the cost of efforts. Evaluation and assessment will also monitor progress and will be used to generate and sustain support with external stakeholders, agencies and the broader ranching and conservation community.

Practice specific considerations

Range riding: A range rider should evaluate and re-evaluate risk over space and time by monitoring livestock and predator use of landscape including any seasonal changes in use or behavior. Effort should increase proportional to depredation risk. These changes could include increased carcass detection effort or a change in riding patterns or riding at different times of day. Once chronic depredations are established a transition to different techniques may be prudent.

Carcass management: As risk increases the activities and intensity of conflict prevention effort should increase. In times of greater need, calving or severe weather for example, efforts to continually remove carcasses from the landscape and place them in a secure location increase. In addition to assessing changing risk on the landscape, those who participate and manage conflict management programs should seek to streamline the phases of carcass management for participants. Whether resources are lacking to secure carcasses, trust has not yet been established with a carcass pickup driver or producers lack time or resources to drop off at a centralized location, the community or individuals participating can work to address barriers in implementation.

Fencing: Particular attention should be given to maintaining fencing infrastructure for effectiveness. Turbo-fladry is a practice that requires frequent monitoring to ensure that the fence maintains charge, does not blow down in the wind or gets flattened by snow. Further, 5 and 4-wire fencing and drive over mats require regular monitoring and maintenance, although this can be far less intensive than fladry.

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Appendices

1. **Consideration for context-specific application of range riding**

Determining an effective strategy for range riding includes assessment of local conditions, vegetation, topography, predator presence, and livestock management goals. The application of range riding can vary greatly depending on these factors, leading to differences in riding techniques, intensity, transportation methods and focus areas. Here we provide a breakdown of key considerations and strategies for range riding application:

A. **Context is key:** Different regions will have unique landscapes and ecological dynamics impacting the strategies employed by range riders. Working off of the risk assessment framework, factors such as vegetation type, terrain ruggedness and predator populations will influence riding techniques and priorities.

B. **Conflict evaluation:** Determining the level of existing and potential predator conflict is key. Signs of low to no conflict may include calm herds with cows and calves paired, cows evenly spread out across the pastures to graze, herds using high quality and/or quantity forage areas, livestock spending the majority of their time with their heads down grazing, little to no predator signs in the area and/or little to no reaction from livestock to herding dogs, although these signs will be unique to each herd. When conflict risk is low, a producer may prioritize using riders to optimize forage use and range conditions for the best possible gains, herd health and range resilience/future productivity rather than monitoring and managing predators. Early detection of potential conflict signs, such as stress in the herd or increased predator activity, allows for timely intervention and/or reporting for compensation. When detected, conflicts can be addressed using non-lethal or lethal methods on predators depending on the regulatory context and severity of conflict. For example, riders focused on preventing new conflicts may prioritize monitoring predator activity while also managing herd health and forage use, whereas a rider working to address existing conflict may focus on predator hazing, providing herd presence during prime conflict hours and/or searching for depredations.

C. **"Riding the predator", and/or "riding the livestock":** The type and age class of livestock, as well as the specific goals of the producer, will shape the focus of range riding efforts. Some producers may prioritize "riding the predator' (e.g., focusing on predator monitoring and deterrence) while others may focus more on "riding the livestock" (e.g., focusing on livestock health and grazing rotation) to increase herd resilience to predation. While the focus of one rider may shift between predator and livestock management, integrating both approaches is often most effective. This integration requires understanding both predator and cattle behavior, adapting riding strategies accordingly and regular communication between producers and riders.

D. **Variation in riding strategies:** Range riding strategies can include variations in timing (e.g., time of day, days per week, hours per day), mode of travel (e.g., horse, ATV, foot), and use of monitoring and management tools (e.g., remote cameras, track and sign identification, herding techniques). The choice of transportation, whether horseback, on foot or using vehicles, depends on factors like pasture scale, accessibility and operational preferences.

E. **Tools for conflict monitoring:** Game cameras and track/scat identification can be especially effective tools for identifying increasing risk by providing information on predators and livestock. Game cameras can be placed in predator travel corridors like roads or game trails, fence lines, water sources, edge habitat (like tree lines), previous locations where predators were observed or around carcasses and/or areas of previous conflict. Cameras can also be placed in areas of high use by livestock to monitor stress, use and activity. Tracking skills can help identify how recently predators have been in the area, whether scats contain livestock hair, whether livestock were killed or scavenged by predators or whether livestock have been chased. It's important to note that the unique behavior of the individual predators may also influence responsiveness to riding efforts. Getting to know *your* predators through regular monitoring and observation of predator response to rider activity may make riding more effective.

2. How to establish a carcass composting site

The following section offers a list of information for supporting exploration and applications of carcass composting facilities. This list has been adapted from the Prairie City Oregon Composting Facility Operations and Maintenance Manual published by ODOT in December of 2019.

A. **Permitting and composting plan:** Permits must be in place as required by the regulatory bodies, whether that be the Department of Environmental Quality (DEQ) or the local land use authorities. The state department of transportation maintenance office can often offer support through the permitting process. In some states, DEQ does not require a composting permit if you compost less than 20 tons of feedstock annually. Composting permits typically include a thorough compost site and operation plan. This plan consists of a guidance document as well as additional documents including maps, property descriptions, site plans and written descriptions of composting details or activities not provided in the operation plan.

B. **Location:** The site should be located in a well-drained site with little to no slope, at least 300 feet from waterways and wetlands and not within a floodplain. While an isolated site is best, if near other facilities or residences, it should be screened and obstructed from view with consideration of prevailing wind directions, though odor and scavengers can be significantly limited with best management practices.

C. **Components and construction:** Sites require a paved surface (asphalt, concrete, or compacted asphalt). Composting bins are most often constructed on top of the paved surface with walls made from Jersey barriers. The number of bins and size of paved surface will depend on the number of carcasses to be composted but four bins on a SO ft. square pad (approx.) will be typical for small composting operations. Bin width is often 20 x 20 ft, but should be at least twice the width of the blade or bucket on the equipment you'll be using. The site should be enclosed with proper fencing to exclude scavengers.

D. **Bulking agents.** Wood chips, straw, sawdust or compost can be used as a bulking agent, as each of these components has a high C:N ratio, and has a large enough particle size to allow for air flow, but not so large that it cools the pile. Sawdust can be eroded by wind, though placing wood chips on the exterior can help mitigate material loss.

E. **Equipment required:** Bulking material (finished compost, woodchips, sawdust, straw or combination of materials), tall chain link fence with barbed wire top surrounding the facility, large chain link gates, starter compost material, 3 to 4-foot probe thermometer and water supply. Where there is no water access, a water tank with a hose set up so you can spray the pile and/or bulking material is an option. A loader, Jersey barrier (or equivalent) for constructing bins., asphalt, concrete, or asphalt grindings to make a hard base surface for the bins. Latex or vinyl gloves for handling material, composting logbook or log sheets to record composting data and activities.

F. **Wildlife disease considerations:** In areas where Chronic Wasting Disease (CWD) is prevalent and carcass composting sites accept wild game carcasses, it is important to consider that the prions that cause CWD do not break down in the composting process. If a facility accepts wildlife carcasses in addition to livestock carcasses, the wildlife compost must be kept separate from the livestock compost, and the equipment used to tend the compost must be separate as well. For example, in Montana, it is required that wildlife carcasses be composted separately from livestock carcasses. Additionally, it is important to consider appropriate use of the finished compost product to prevent spread of CWD.

3. Electric fencing resource guides

Installing Turbo Fladry: An Informational Guide
https://www.nrdc.org/sites/default/files/installing-turbo-fladry-guide-ib.pdf

A Landowner's Guide to Wildlife Friendly Fences: How to Build with Wildlife in Mind
https://fwp.mt.gov/binaries/content/assets/fwp/conservation/land-owner-wildlife-resources/a_landowners_guide_to_wildlife_friendly_fences.pdf

Electric Fence https://blackfootchallenge.org/electric-fence/

Living **with** Livestock and Wolves: A practical Guide to Avoiding Conflict through Non-lethal Means
http://westernwildlife.org/wp-content/uploads/2015/10/Fact-Sheet-5-Fencing-Fladry-and-Night-penning.pdf

Fencing https://peopleandcarnivores.org/fencing

Fladry https://peopleandcarnivores.org/fladry

A Beginners Guide to Raising Sheep http://www.sheeplOl.info/201/predatorcontrol.html

Deterring Bears with Electrified Fencing: A Beginners Guide
mfwp_electric-fencing-guide_march-2017.pdf (mt.gov)

How to Electric Fence for Bears: https://www.youtube.com/watch?v=lqIRMavnahE

Practical Electric Fencing Resource Guide: Controlling Predators electric_fence_2013.pdf - Google Drive

Predator Behavior Modification Tools for Wildlife Professionals: mgt_2013.pdf - Google Drive

Tool Resource Guide:
https://staticl.squarespace.com/static/Sf222a7c92ce383c8ff73e83/t/Sf5d6dle9e32a319f536ac78/1599958304404/PC-Tool-Resource-Guide.pdf

Electrified Fladry for Deterrence of Grey Wolves (*Canis lupus):*
staticl.squarespace.com/static/Sf222a7c92ce383c8ff73e83/t/Sf5d6d4388ce6e3f57692eal/1599958354157/FladryManual.pdf

A Hands-on Resource Guide to Reduce Depredations:
https://staticl.squarespace.com/static/Sf222a7c92ce383c8ff73e83/t/Sf5d6d30e9d120579bfa1968/1599958326035/WolfResourcesGuide.pdf

Livestock **and** Wolves: A Guide to Nonlethal Tools and Methods to Reduce Conflict:
https://defenders.org/sites/default/files/publications/livestock_and_wolves.pdf