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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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.


Wolf chasing elk in Montana's Madison Valley

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 of livestock 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 depredating wolves and removal of individual bears known to be depredating 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 depredating 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 can be 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 may incorporate 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

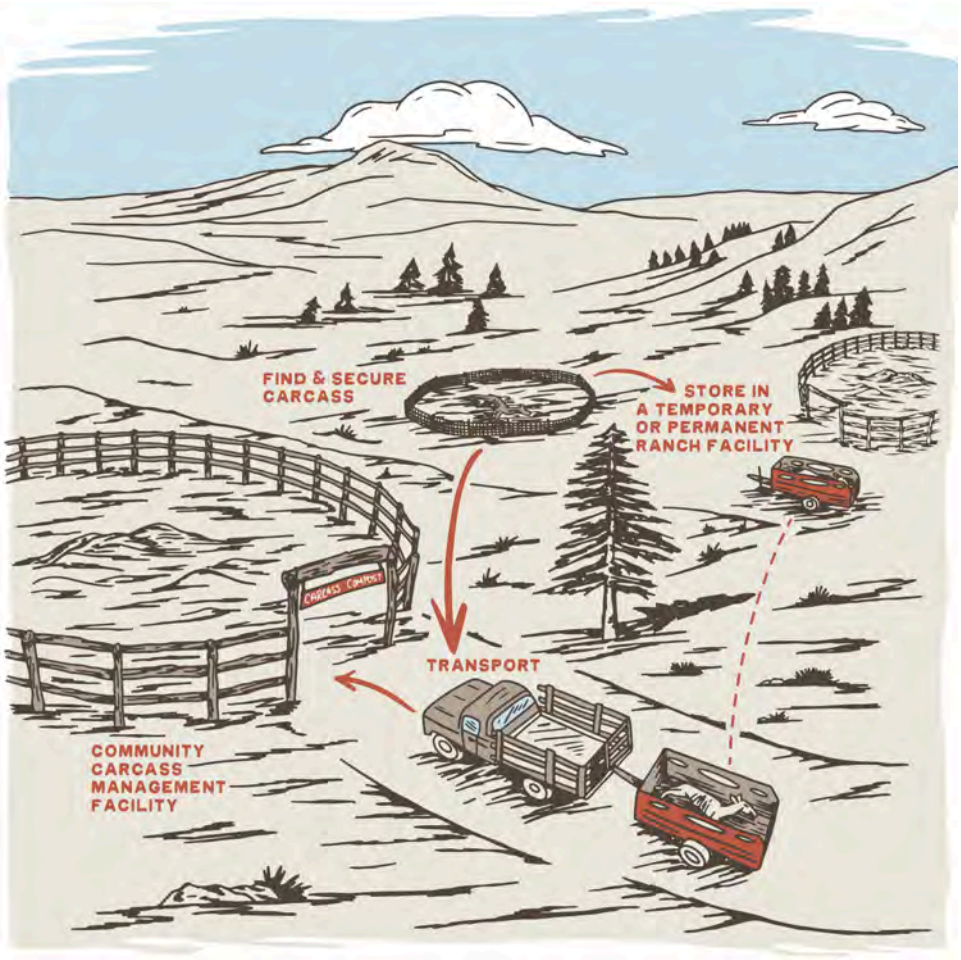

Figure 2. Carcass management

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

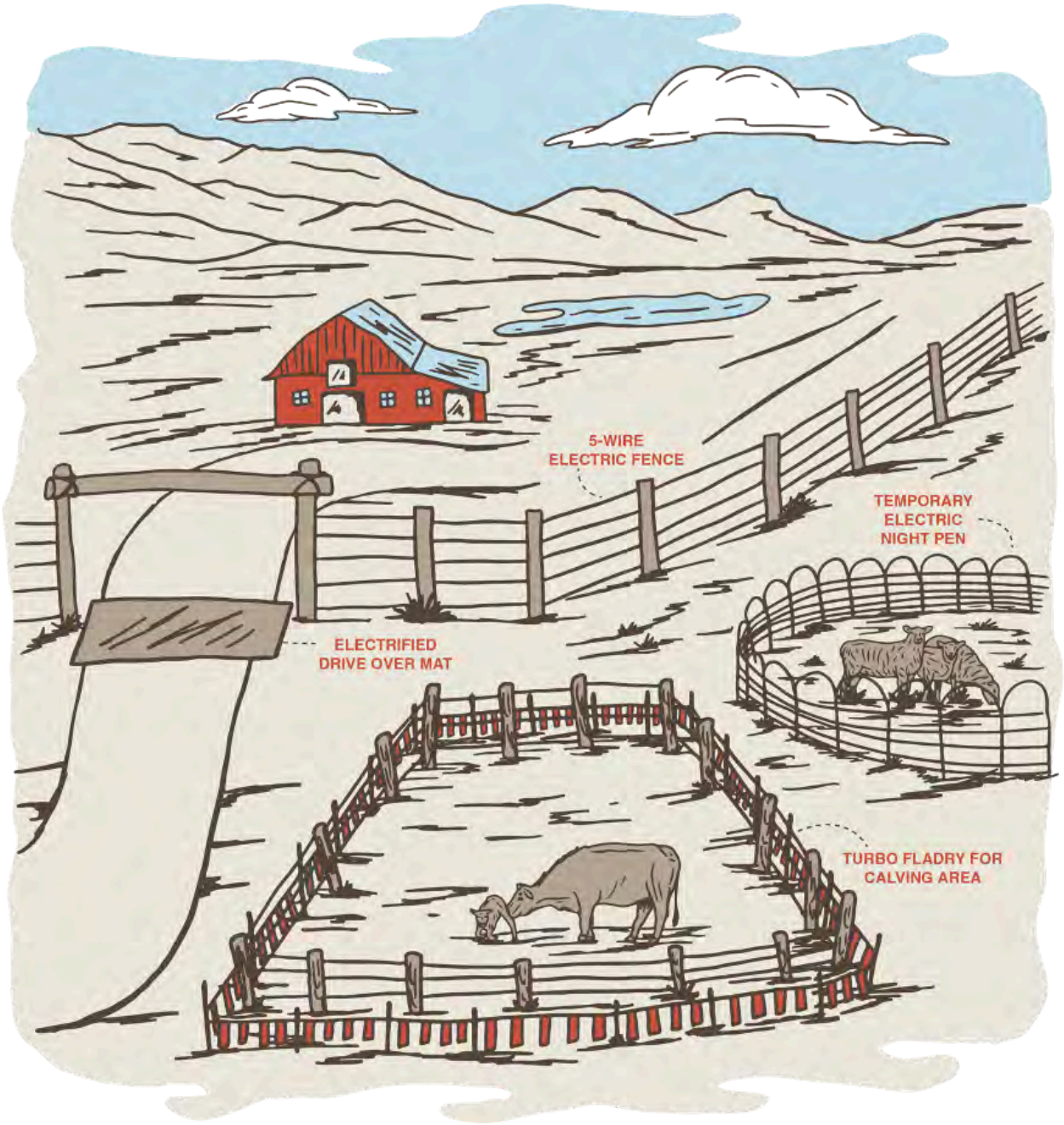

Figure 3. Electric fencing

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.

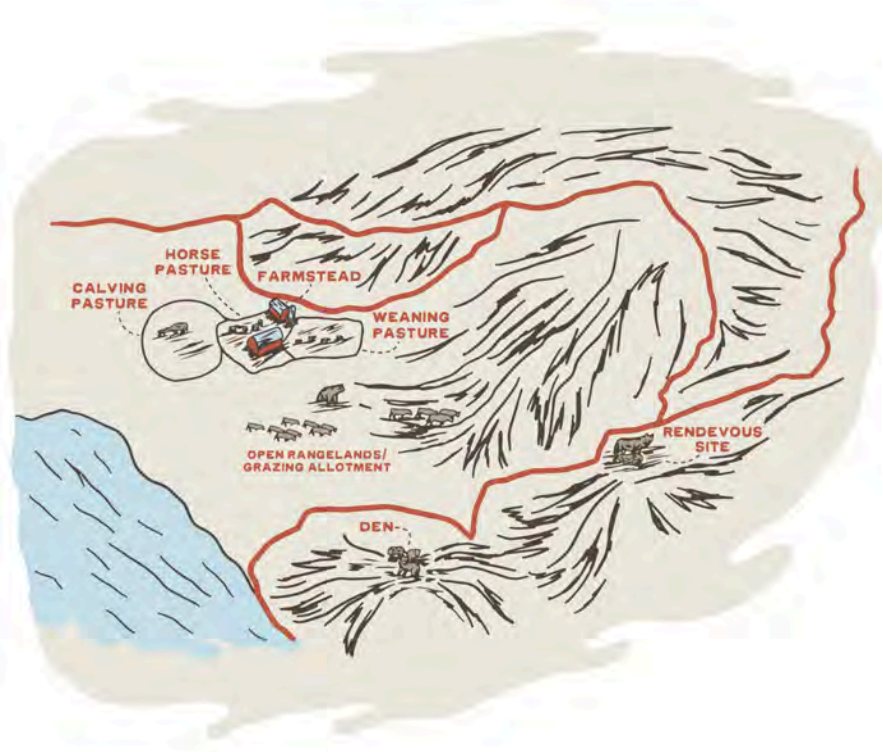

Figure 4. Landscape stratification through risk assessment

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

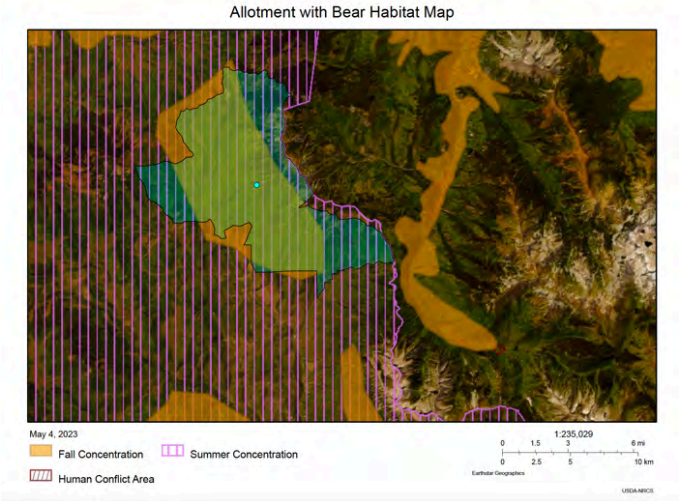

Figure 5: Map indicating allotment location, summer concentrations of black bears, and human conflict areas.

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).

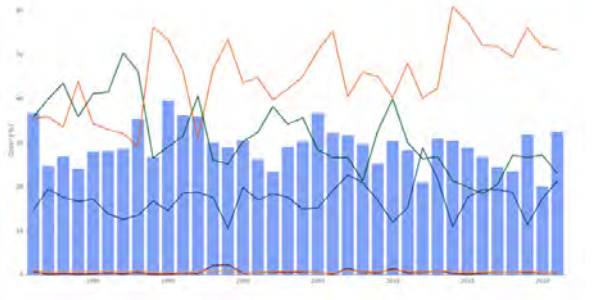

Figure 6: Rangeland Analysis Platform data indicating increasing tree cover on allotments (30 to 50%) and decline in perennial forb and grass cover (40% to 25%)

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.

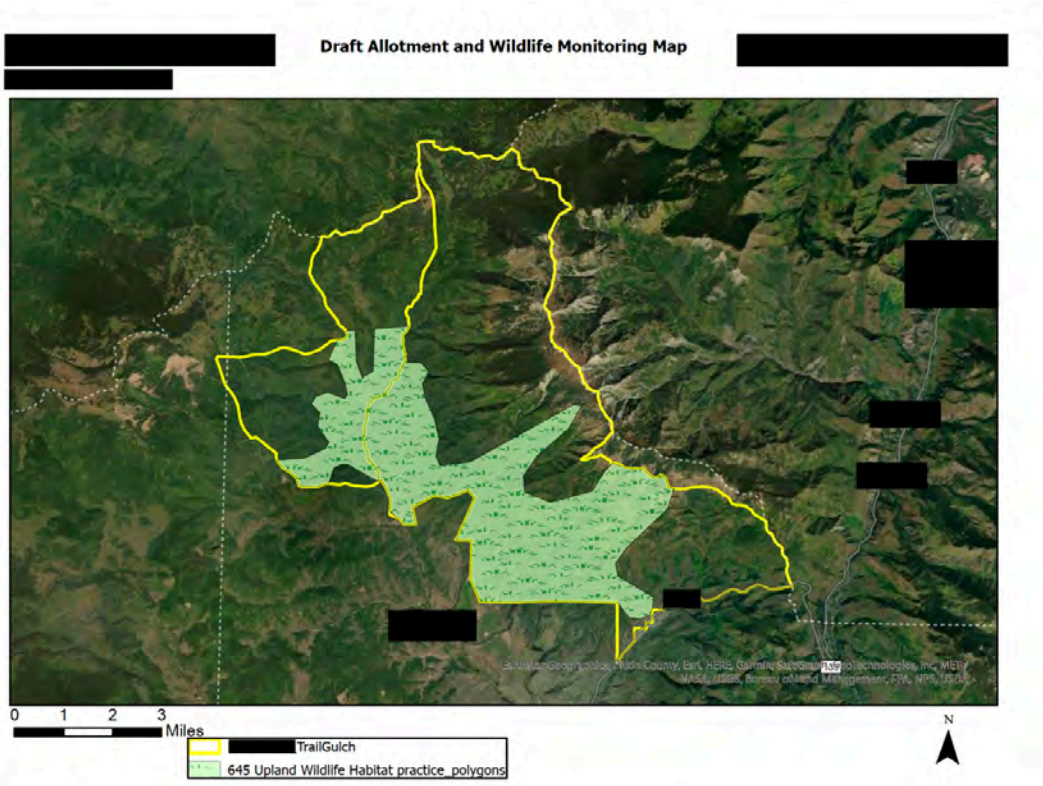

Figure 7: Map identifying the area of upland wildlife habitat management implementation, created from producer-identified conflict hots-spots.

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 of livestock).

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 of livestock 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 of livestock 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 of local 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 of life 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 specked 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 50 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.sheep101.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://static1.squarespace.com/static/5f222a7c92ce383c8ff73e83/t/5f5d6d1e9e32a319f536ac78/1599958304404/PC-Tool-Resource-Guide.pdf

Electrified Fladry for Deterrence of Grey Wolves (*Canis lupus*):
static1.squarespace.com/static/5f222a7c92ce383c8ff73e83/t/5f5d6d4388ce6e3f57692ea1/1599958354157/FladryManual.pdf

A Hands-on Resource Guide to Reduce Depredations:
https://static1.squarespace.com/static/5f222a7c92ce383c8ff73e83/t/5f5d6d30e9d120579bfa1968/1599958326035/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