

THESIS

A DECISION AID FOR ESTIMATING FINANCIAL FEASIBILITY OF NON-LETHAL WOLF-
LIVESTOCK CONFLICT PREVENTION PRACTICES

Submitted by

Mia Morones

Department of Agricultural and Resource Economics

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Master's Committee:

Advisor: Dana Hoag

Co-Advisor: Daniel Mooney

Jonathan Salerno

Stewart Breck

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ABSTRACT

A DECISION AID FOR ESTIMATING FINANCIAL FEASIBILITY OF NON-LETHAL WOLF-LIVESTOCK CONFLICT PREVENTION PRACTICES

U.S. Reintroduction efforts of the gray wolf (*Canis lupus*) have contributed to negative externalities that disproportionately fall onto producers in the form of direct and indirect costs due to wolf-livestock predations. Direct costs incurred by livestock owners include market value losses due to livestock death, veterinary costs for injured livestock, and transaction costs associated with carcass management. Indirect costs also occur, such as reduced livestock weight, reduced milk production, and decreased pregnancies from livestock stress responses due to wolf presence. These losses, while not widespread, can be costly to those that experience them. However, there are non-lethal predation prevention practices that can be effective in reducing wolf-livestock conflict. Some of these practices include turbo fladry, electrified night penning, range riding, carcass composting, livestock guardian dogs and more. While there is a great deal of literature about these practices, uncertainty remains regarding their financial feasibility for producers.

To help livestock producers manage their risk, this study develops a framework for determining the feasibility of these practices by combining the producer's risk probability of wolf-livestock conflict with their respective costs to implement prevention and mitigation practices of interest. To implement the framework, I develop an online decision aid that provides comparative break-even analysis to offer producers a metric to understand how effective their mitigation practice(s) must be to offset the potential costs associated with livestock predation. The tool provides an estimate of the probability of conflicts for specific properties based on local conditions such as habitat and presence of wildlife and livestock and helps users identify the cost of various mitigation tools and the value that might be lost in a conflict. Additionally, this analysis implements sensitivity analysis and Monte Carlo Simulation (MSC) to better

understand how impactful varying inputs such as material costs, predation risk and state funding for practice implementation are on the financial outcomes of the model.

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1 – Introduction

1.1 Wolf Reintroduction

The reintroduction of gray wolves to the American west has been tumultuous with widespread divisiveness, changes in laws and regulations and a disproportionate cost burden incurred by livestock producers. Nonetheless, natural repopulation alongside reintroduction and conservation efforts have led to an increase in wolf presence, primarily within northwest and north central regions of the United States. In 1995, a major gray wolf reintroduction effort was initiated in the Yellowstone National Park and the Greater Yellowstone Ecosystem (GYE) and in central Idaho. Over the course of 1995 and 1996, a total of 66 wolves were released with 31 being relocated within YNP and 35 within central Idaho (Hayden, J., 2017). Only seven years after the reintroduction of gray wolves to the Northern Rocky Mountain Region, the gray wolf population met the biological recovery goals federally enforced which consisted of a minimum of 100 wolves and 10 breeding pairs. By 2008, it was estimated that there were approximately 846 wolves that inhabited Idaho (Idaho Department of Fish and Game, 2009).

Due to success from the wolf reintroduction in YNP and central Idaho, gray wolves were officially removed from protection under the Endangered Species Act in Montana and Idaho in May of 2011 as the reintroduction efforts in Yellowstone and Idaho proved to be effective. Following a court order, the USFWS also officially delisted the gray wolf under the ESA in Wyoming on March 3rd of 2017 after years of meeting minimum biological requirements (U.S. Fish and Wildlife Service, 2017). U.S. Fish and Wildlife Service, (2024) estimated there were approximately 2,797 wolves aggregated into 286 packs located across seven states within the western US as of 2022.

The most recent reintroduction efforts for gray wolves have occurred in Western Colorado. Proposition 114, the Reintroduction and Management of Gray Wolves to Colorado, first appeared on

ballots in November of 2020. The initiative, now state statute 33-2-105.8, passed on November 3rd, 2020. The proposition was politically factious with only 50.9 percent of the eligible voter population voting in favor of its passing (Colorado Secretary of State, 2020). This proposition declared that Colorado Parks and Wildlife (CPW) create a comprehensive plan to reintroduce gray wolves into Colorado, west of the Continental Divide as well as facilitate a management plan no later than Dec. 31st of 2023 to ensure that introduced wolf packs could establish a self-sustaining population (Colorado Parks and Wildlife, 2024).

CPW has since created a comprehensive plan which aims to release between 30-50 wolves over a course of 3-5 years, beginning in December of 2023 with releases expected to occur between December and March every year (Colorado Parks and Wildlife, 2022). Since the enactment of the statute, CPW sourced 10 wolves from Oregon and released them in Colorado's Summit and Grand counties during late December of 2023 (Colorado Parks and Wildlife, 2024). The second batch of wolves were sourced from British Columbia, Canada and reintroduced to Colorado's Eagle and Pitkin counties on January 12th, 14th and 16th of 2025. There were seven male, and eight female wolves released in Eagle and Pitkin counties Colorado Parks and Wildlife (2025).

1.2 Wolf Predation

It has been about three decades since wolves were reintroduced to YNP and central Idaho, and although populations have made healthy returns, wolf-livestock predation events have become a frequent consequence. Figure 1.1 displays Idaho's wolf-livestock predation investigations and confirmed losses over a span of 6 years from 2016 to 2022 (Wolf Depredation Control Board, 2019 & 2022). The blue data series represents the yearly number of investigations for suspected wolf-livestock predations within the state. The green data series represents number of investigations that resulted in a confirmed wolf kill. Similarly, Figure 1.2 shows Montana's livestock losses due to suspected wolf attacks. This data is gleaned from Montana's Department of Livestock – Livestock Loss Statistics (Montana Department of Livestock, 2025). In this case the blue data series represents all probable and confirmed losses due to wolves while the green data series represents all losses confirmed to be wolf predation. Both states show a similar trend

with predations peaking in 2019-2020 with slow decreasing trends following. It is also important to note that these data only show investigation results and do not include any livestock losses that were not discovered or not reported.

Colorado has just recently begun its reintroduction efforts and thus wolf predations have been relatively low compared to other states with a higher wolf presence. Figure 1.3 outlines predation incidents in Colorado from 2022-2024 sandwiched between one late December 2021 predation and one early February 2025 predation recorded from CPW’s Confirmed Wolf Depredations (Colorado Parks and Wildlife, 2024). As can be expected, there is a slight spike in predation incidents with 14 reported livestock losses in 2022, four reported livestock losses in 2023, and 27 reported livestock losses in 2024. This increase in 2024 is assumed to be a result of the December 2023 reintroduction of wolves in Colorado’s Summit and Grand counties.

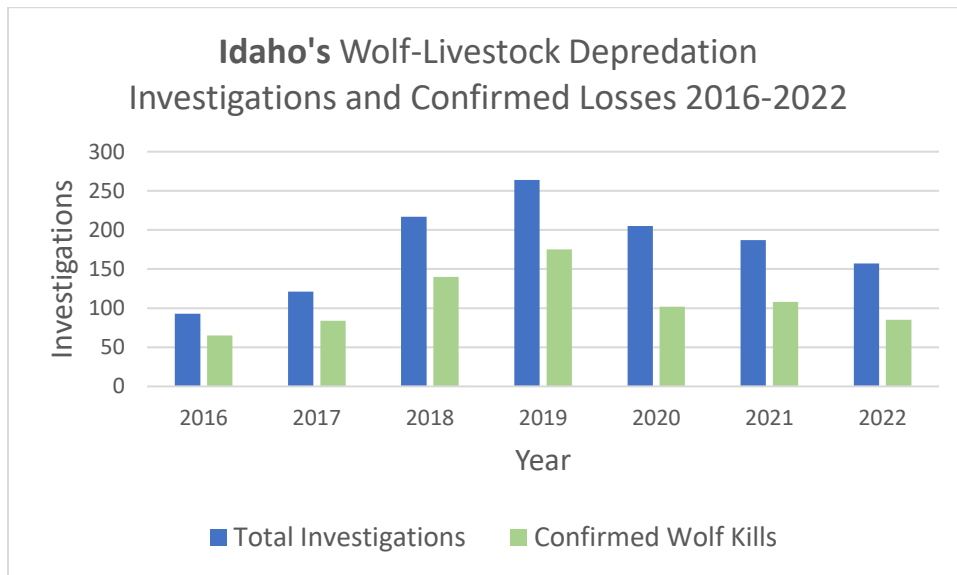


Figure 1.1 - Data retrieved from Idaho’s Wolf Depredation Control Board Performance Reports from 2016-2019 and 2019-2022.

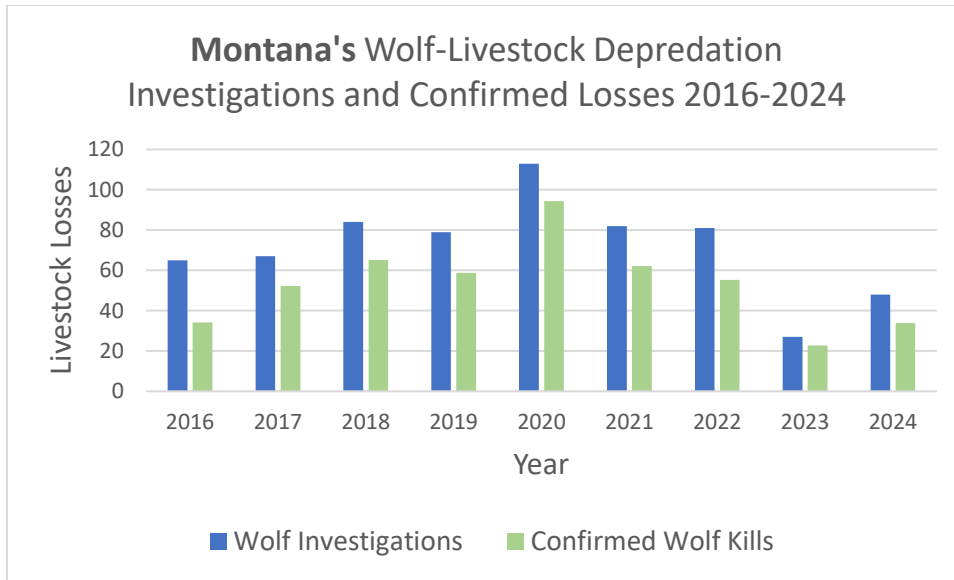


Figure 1.2 - Data retrieved from Montana's Department of Livestock – Livestock Loss Statistics.

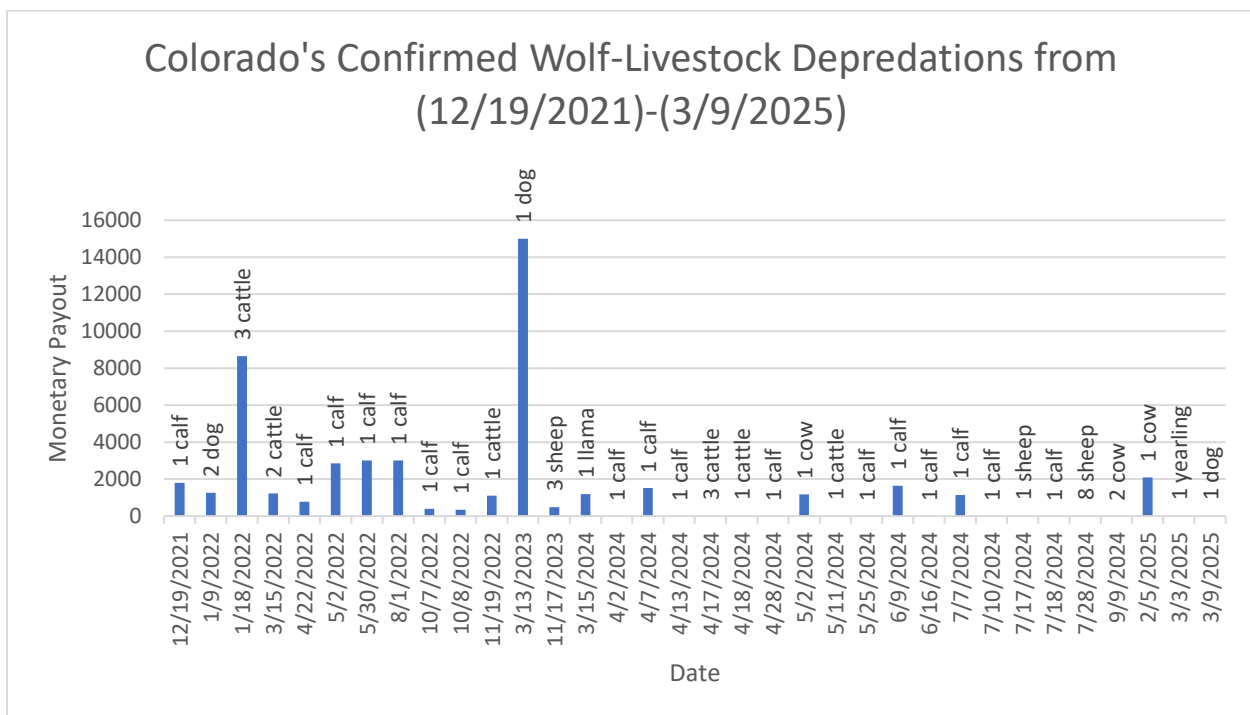


Figure 1.3 - Data retrieved from Colorado Parks and Wildlife's Confirmed Wolf Depredation Stats. Claims last updated from CPW website on 4/20/25 and pending payout are subject to be updated and vary from the above graph.

1.3 Cost Incurrence

Wolf repopulation introduces several risks to producers in the form of direct and indirect costs to livestock. The most obvious costs related to wolf predation are the direct market value loss from one less livestock animal as well as veterinary costs to treat injured animals. Most state compensation programs compensate producers for the “fair market value” (FMV) of depredated livestock based on pricing from current USDA market reports. Livestock pricing will vary with market trends and fluctuations as well as characteristics such as age, weight, and breed quality of the animal, but still general pricing trends persist. More likely, smaller livestock animals like calves, yearlings, heifers, and sheep will be depredated.

Based on a May 12th, 2025, report for Colorado’s Livestock Auction Summary Report from the USDA’s Agricultural Marketing Service (AMS) medium and large heifers ranged from \$875-\$2,300, while medium and large cow-calf pairs ranged from \$3,060-\$4,000 (U.S. Department of Agriculture Economics, Statistics and Market Information System, 2025). Similarly, Montana’s May 12th Livestock Auction Summary Report valued medium and large heifers from \$1,245-\$2,037, while medium and large cow-calf pairs ranged from \$2,925-\$3,750 (U.S. Department of Agriculture - Agricultural Marketing Service, 2025). Colorado’s April 30th Centennial Livestock Auction Report for sheep and goats showed prices ranging from \$100-\$300 depending on age, weight, sex, and breed (Centennial Livestock Auction Co., 2025, May 1). Montana’s April 28th report showed slaughter sheep ranged from \$200-\$260, while feeder sheep typically ranged from \$200-\$250 (U.S. Department of Agriculture - Agricultural Marketing Service, 2025).

Wolf-livestock conflict can affect producer financially beyond just livestock injury and death. The presence of wolves can negatively impact livestock through the induction of stress. These stress responses in livestock can present outcomes of reduced cattle weight, decreased milk production, decreased pregnancies and increased risk of infection. This phenomenon has been reported among producers and observed in studies (Cooke et al., 2013; Nickerson et al., 2024; Macon, 2020). Despite the observed presence of indirect costs, only a handful of studies have estimated values for these indirect costs (Steele

et al., 2013), (Widman et al., 2019), and (Ramler et al., 2014). Steele et al. (2013) found that indirect costs due to wolf presence effects (which are often not included in compensation programs) were often comparable to, if not greater than direct costs faced by producers from wolf predation. Widman et al. (2019) observed the negative impact of carnivore abundance on sheep reproduction among average-sized sheep operations (~31 ewes) in Sweden based on low and high predator densities. Areas with high predator presence experienced additional annual costs from decreased reproduction estimated at EUR700/year (Approx. USD810/year). Most interestingly, their study found roughly 75% of indirect costs from increased predator presence came from increased labor time searching for and retrieving lost livestock.

1.4 Livestock Compensation

Typically, a livestock owner is mandated to report a livestock predation within 24 hours of discovery if they want to later be able to file a claim for livestock loss compensation. The process to confirm a livestock loss can be tedious. If a producer decides to file a claim to seek compensation, they must have a formal investigation carried out by wildlife service personnel or the equivalent for their respective state. As of the beginning of 2025, states that currently have wolf-livestock predation compensation programs are Arizona, California, Colorado, Idaho, Michigan, Minnesota, Montana, New Mexico, Oregon, Washington, Wisconsin and Wyoming. Typically, state organizations will apply to federal funding, which when awarded, can then be distributed to producers as compensation through the states' independent processes. Requirements to receive compensation and the extent of scenarios eligible for payout vary significantly by the state. See Table 1 and Table 2 below for state compensation comparison.

Table 1 – Compensation Program Comparisons for AZ, CA, CO, ID, MI, and MN

State:	Arizona	California	Colorado	Idaho	Michigan	Minnesota
Compensation amount:	standard calculation approach based on FMV	FMV determined by USDA value determinations or executed sale contract	100% FMV up to \$15,000 per animal	Paid at 100% FMV.	100% FMV up to \$4000 per animal	University of Minnesota Extension determines the market value of the livestock lost
Compensation for confirmed wolf kill:	Yes	Yes	Yes	Yes	Yes	Yes
Compensation for probable wolf kill:	Yes	Yes	Yes	Funding dependent	No	No
Compensation multiplier:	No	No	Yes, producers are able to seek compensation for multiple missing livestock animals relative to each confirmed wolf predation.	No	Yes, only if the producer has a prior history of payout from a previously confirmed wolf predation.	No
Compensation for indirect losses:	No	No	Yes, via an itemized production losses option	No	No	No
Extra Stipulations:	No	No	No	Yes, documentation of 50% cash match or in-kind matching contributions for livestock losses required by the producer	No	Yes, A producer cannot receive payments less than \$100 and more than \$20,000 in a single fiscal year.
Website:	State of Arizona Livestock Loss Board	CDFW Wolf Livestock Compensation Grants	Wolf Depredation Colorado Parks and Wildlife	Wolf Conflict Funding Species Conservation	Michigan Wildlife Depredations Indemnification Act	Wolf Depredation Compensation Minnesota Department of Agriculture

*Funding is on a first come, first serve basis. Compensation is limited to the state’s yearly available funds and scenarios eligible for payout are subject to change at the discretion of the state.

Table 2 – Compensation Program Comparisons for MT, NM, OR, WA, WI and WY

State:	Montana	New Mexico	Oregon	Washington	Wisconsin	Wyoming
Compensation amount:	100% FMV of recent billings ⁷ USDA Market Report.	FMV of livestock. Compensation is dependent on available funding.	Paid at 100% FMV.	FMV as determined by consultation with recognized livestock organizations and the Department of Agriculture.	Paid at 100% FMV.	The FMV for like livestock at a rate substantiated by a livestock sale barn on the date of damage.
Compensation for confirmed wolf kill:	Yes	Yes	Yes	Yes	Yes	Yes
Compensation for probable wolf kill:	Yes	Funding dependent.	County dependent	50% FMV on acreages less than 100 acres and 100% FMV on acreages at or greater than 100 acres	Yes	Yes, if the damage was more likely than not caused by gray wolves as determined by a WS investigator.
Compensation multiplier:	No	No	Yes, you can file claims for missing livestock with compensation at 50% FMV.	Yes, a confirmed kill on acreage over 100 acres will be compensated at 2x the verified losses.	Yes	Yes, there is a 7:1 payout ratio for wolf depredated calves and sheep in trophy region
Compensation for indirect losses:	No	Funding dependent.	No	No	No	No
Extra Stipulations:	No	Funding available only to all lands in New Mexico south of I-40.	Yes, claimants must reside in a county that has previously established a commission for a wolf predation compensation program.	Yes, only claims of \$500 or more may be filed.		Yes, regulation differs as wolves are considered trophy game or predatory animals depending on region.
Website:	Livestock Loss Board	County Livestock Loss Association	Oregon Department of Agriculture: Wolf Depredation Grant	Washington Department of Fish & Wildlife	Wisconsin DNR - Gray wolf depredation reports and maps	Wolves in Wyoming Wyoming Game & Fish Department

*Funding is on a first come, first serve basis. Compensation is limited to the state’s yearly available funds and scenarios eligible for payout are subject to change at the discretion of the state.

Ultimately, state livestock loss compensation programs for wolf predation rely on available funds and are not always a guarantee. All 12 states offer compensation for confirmed wolf kills, however, probable wolf kill coverage is broadly variable. There is some variation in livestock covered by state, but typically livestock classification consists of cattle, horses, mules, burros, sheep, lambs, swine, llamas, alpacas, and goats as well as guard/herding animals.

Documentation shows that losses of calves, yearlings, and sheep can be difficult to detect, especially in larger operations where locating animal remains is often challenging (Nickerson et al., 2024). Less than half of the states with compensation programs offer some sort of multiplier for livestock that is missing due to wolf predation. To be eligible for compensation for missing livestock you must in every case first have proof of a confirmed wolf kill. Colorado has one of the more comprehensive compensation multipliers allowing a livestock owner to potentially be compensated 100% fair market value (FMV) for one required proven death as well as 100% FMV for each accompanying suspected death of calves or sheep up until a max quantity of seven.

Michigan provides indemnification for missing animals only if there is a history of losses via a documented prior payment by the department due to the death or injury of livestock from wolves. A producer must also provide a notarized statement specifying the date of birth of each missing animal and the date on which the animals were discovered missing (Michigan Legislature, 2012). Oregon allows claims to be filed for missing livestock, with compensation typically at 50% FMV or less than the payout of a proven depredated livestock animal. Producers must also document that other causes for missing livestock are not present (Oregon Secretary of State, n.d.). Likewise, Wisconsin producers are eligible for reimbursement for up to five additional missing calves per verified wolf predation (Wisconsin Department of Natural Resources, n.d.). Lastly, Washington is more unique in their policy, compensating all proven losses on acreage that makes up less than 100 acres as long as the loss value totals over \$500. If a producer has a confirmed loss(es) on land over 100 acres, they are compensated at a rate of twice the verified losses (Washington Department of Fish & Wildlife, n.d.).

Colorado is unique in that they allow producers to submit itemized production losses for potential reimbursement. Production losses have the possibility to result in a larger payout as they account for additional indirect losses such as decreased dressing weights, decreased conception weights, lowered milk production, etc. However, the documentation and form submittal process are more extensive. Similar to the states' compensation ratios, there must be a proven predation event (injury or death). The livestock

owner must also submit documentation such as photo evidence of wolf presence (scat, tracks, etc.), a baseline death loss percentage for livestock for a minimum of three years, preceding wolf presence, records for current year vaccination status of livestock, livestock headcounts at the beginning and end of the season as well as the number of animals that have died from other factors or predators over the course of the grazing season.

1.5 Research Questions and Objectives

Given uncertainty about the risk of conflict and about the cost of protection, some producers are likely to spend more money to protect themselves than can be justified by the risk and others will spend too little. The objective of this study is to create an interactive online decision aid that producers can utilize when determining if implementation of non-lethal predation prevention practices for wolf-livestock conflict are financially feasible for them. This study seeks to use a sophisticated ecological modeling tool with extensive data on conflicts to estimate the likelihood of livestock losses for any location in a state that has wolves to compute the benefits of mitigation and compare it to the costs of basic prevention practices using a comprehensive budgeting exercise. The tool will then use a comparative break-even analysis to observe scenarios where implementation of predation prevention practices would result in financially beneficial outcomes for producers. The tool is provided separately and is not yet published at the time of this writing.

Since there is so much uncertainty about many of the factors that go into the model, users will have the luxury of being able to change values easily to compare how these changes affect results. For example, if they are unsure about the cost of a mitigation practice, they can start by using the value calculated by the model, then try something a little higher or a little lower. The impact on results will reveal how important it might be to be accurate. I only have the option here of presenting examples. Therefore, what I present are examples based on a representative operation in a western state in 2025. In order to demonstrate a broader range of results, I use Monte Carlo Sensitivity analysis to analyze how various sources of uncertainty such as price of inputs, varying levels of predation risk and government

funding for deterrence or compensation affect my results. I can then deduce from these examples major trends and lessons to better understand what makes mitigation feasible. However, these lessons are based on the examples I review and should not be assumed to always uniformly apply to all places, operations or situations.

2 – Literature Review

2.1 Wolf Predation Literature

There is ample literature that discusses the occurrence of wolf predation within the United States. Hanley et al., (2017) estimated risk probability of predation for current and probable wolf occupied areas in Washington, Montana and Idaho based on data such as grazing land cover types, wolf pack demographic information, cattle size, allotment size and recorded predation events. Similarly, Clark et al., (2020) observed spatial relationships between cattle and wolf presence patterns in cattle grazing allotments in western Idaho to classify and map wolf cattle encounter risk for 5 classes (very high to very low). Their study found that in most of the study sites, 75% of confirmed wolf predations occurred in areas identified as high or very high-risk using predictor variable data layers like terrain slope, vegetation greenness, and distance from perennial streams.

On a more global scale, (Janeiro-Otero et al., 2020) conducted a meta-analysis of 119 gray wolf dietary studies across 27 countries to gauge how wild prey and livestock densities impact dietary preferences of gray wolves. The analysis determined that typically, wolves went after ungulate prey over domesticated livestock even in areas where livestock population was greater, however, smaller, unattended herds of cattle and other livestock were at more risk of predation. A study from Denmark and the German federal state Schleswig-Holstein, investigated the predation rates of 43 wolves via genotyping to determine behavioral patterns of resident and non-resident wolves. The study found wolves primarily

killed livestock as a situation or context-dependent response, i.e., non-resident wolves in agricultural areas with low accessibility of wild ungulate prey and high livestock densities, rather than because of behavioral preferences for sheep (Mayer et al., 2022).

Many published information guides and fact sheets that are available to producers provide critical information on the material, equipment, time and labor requirements for various mitigation practices. These guides are typically published via state organizations, non-profits and university extension groups. The Western Landowners Alliance (2024) has published producer tool kits outlining resources and instructions for carcass composting, range riding and turbo fladry including night penning and drive over mats. The Defenders of Wildlife (2016) also have a publication on Livestock and Wolves: A Guide to Nonlethal Tools and Methods to Reduce Conflicts that gives framework to reduce predator attractants, work with livestock guardian dogs, implement electric barriers, increase human presence in the form of range riders and herders, and the use of deterrent devices.

In rare occasions, producer guides will include some cost information like the partial budgeting form included in the Livestock Mortality Composting for Large and Small Operations in the Semi-arid West by SARR (Sustainable Agriculture Research and Education, 2011). (Texas A&M AGRILIFE Extension (2021), for example, provides a producer guide that estimates the initial cost and subsequent annual costs associated with the purchase of a Livestock Guardian Dog (LGD), but there is no further breakdown by itemized costs. Producer tool kits and guides provide a strong basis for the necessary materials and equipment required for predation prevention practices, but they often do not provide scalable cost breakdowns, annualized costs or associated costs of labor for implementation and maintenance.

This work is the first of our knowledge to create and provide annualized budget sheets for some of the most well-known, non-lethal predation prevention practices. The study will combine financial considerations through break-even analysis and sensitivity analysis to create a tool to inform producers of

the practicality of non-lethal mitigation practice implementation based on their locational risk of wolf conflict and independent costs.

2.2 Wolf Deterrence Practices

There are a multitude of studies that suggest that the implementation of attack prevention measures on livestock grazing lands and pastures could reduce the occurrence of predation of livestock by gray wolves. Janeiro-Otero et al. (2020) conducted an analysis of numerous synthesized studies that examined gray wolf scat to determine biomass of prey species. Their analyses found that predation increased up to 78% in herds that were left unattended and to graze freely without protection. In the northern Apennines of Italy, researchers found that grazing management practices had a significant impact on incidence of predation events, such that one or more periods of free grazing and on pasture cattle birth increased risk of predation. Therefore, night shelter and shelter for females giving birth were an effective measure of predation prevention (Dondina et al., 2014). A study by Stone et al. (2017) observed the effectiveness of practices such as increased human presence, fladry, LGDs, various light and sound devices and radioactivated guard boxes used periodically over a 7-year period in Idaho. They compared the predation rate of this land with the predation rates of adjacent, wolf occupied areas and found that proactive use of multiple nonlethal techniques applied conditionally can decrease predation on large open-range sheep operations.

2.3 MaxEnt Species Distribution Modeling

This study will employ Maximum Entropy (MaxEnt) species distribution modeling to calculate the probability of wolf conflict which will assist comparative break-even calculations later in the results and analysis. MaxEnt was chosen as the favorable species distribution modeling technique as it has proven to be a reputable model in many previous ecosystem and habitat studies, outperforming other similar species distribution models. Ahmadi et al (2022) concluded that MaxEnt had the highest predictive performance compared to other popular models such as the generalized linear model (GLM), gradient boosted model

(GBM), and random forest (RF), while also being listed as the most practical method for dealing with imbalanced-biased data in species distribution modeling approaches. A study that investigated habitat suitability for the Mexican wolf in Mexico and the southwestern United States found similar success using MaxEnt as it was one of the better performing of the modeling algorithms tested in terms of validation metrics (Berhínez-Meyer et al., 2021). Many other recent wolf habitat and distribution studies have utilized MaxEnt as their modeling technique of choice with (Berhanu et al., 2022) stating that they chose MaxEnt for predicting current and future suitable habitat for the Ethiopian wolf due to the model's use of only presence/occurrence data as well as being able to implement both continuous and categorical variables. Other recent wolf distribution studies that have use MaxEnt include (Jhala et al., 2022), (Reshamwala et al., 2022), and (Ulibarrie et al., 2024).

2.4 Monte Carlo Budget Simulation

This study will use comparative break-even analysis as the method to determine whether a mitigation practice or combination of practices will break even or offset the costs that would be incurred from a loss of livestock. To further examine the variability in outcomes and weight of the variables on the financial feasibility, Monte Carlo Simulation (MCS) will be applied for sensitivity analysis. MCS is a common method employed across various fields of study, most typically financial and economic project analysis to determine the financial viability of a project or business venture.

Numerous studies have had success in evaluating price uncertainty by implementing MCS onto agricultural budgets sheets both manually via statistical excel functions or via commercial excel add-on like @Risk. Rayburn (2009) converted a deterministic hay budget into a Monte Carlo budget by implementing excel functions for random number generator and cumulative probability functions to estimate the break-even price for hay needed to offset input costs. Likewise, Amorim et al. (2024) used MCS to forecast cost risks associated with corn and soybean production with the goal of providing agriculturalists with stronger resource allocation decision making ability in the face of uncertainty in materials, labor, and overhead costs. The use of MCS or stochastic budgets to find variability surrounding

break-even points has been prevalent within the literature often with focus on dynamics with inputs, demand and yield. Awondo et al., (2017) modeled break-even year for profitability for muscadine grape production in Georgia, US. Other studies that have used MCS in agricultural related studies include (Trejo-Pech et al., 2024), (Chen et al., 2021), and (Quaicoe et al., 2024).

3 – Methods

3.1 Break-Even Efficiency Model

Within this study, Comparative break-even analysis with Monte Carlo sensitivity analysis were employed to investigate financial viability of the implementation of various instances of non-lethal mitigation practices. Comparative break-even in the traditional sense typically looks at the tipping point where a producer earns net positive profit utilizing a new method or input as compared to an existing method or input. This study is untraditional in that I am comparing the cost of implementing a practice against potential lost income (PLI) a producer would experience from the loss of livestock. The objective is to mitigate the loss of income rather than increase the profit earned. In summary, the break-even estimated here is where the gain in reduced conflict presented by a mitigation practice just equals the cost of that prevention. To estimate PLI the break-even efficiency model implements the risk probability of conflict derived from the MaxEnt species distribution model.

Break-Even Efficiency Model:

$$Re_i(P + T) = \sum_i^I MP_i \quad eq(1)$$

Where:

R = probability of a wolf/livestock conflict (0 to 100%)

e = Efficiency of mitigation practice, i, or combination of a mitigation practices combined (I) (0 to 100% reduction in R)

P = Fair market value/head of the predated animal

T = Transaction cost/head (i.e. additional costs past the market value of the livestock animal)

MP = Cost of management practice, where $i =$:

C_{TF} = Annual cost of turbo fladry installation and maintenance per head (adjust from per mile)

C_{ENP} = Annual cost of electrified night penning per specified herd

C_{LGD} = Annual cost of a livestock guardian dog

C_{RR} = Annual cost of range-riding per head (adjust from range size)

C_{CC} = Annual cost of carcass composting per head

To re-write the equation in terms of break-even efficiency:

$$e = \frac{(\sum_i^I MP_i)}{R * (P + T)} \quad eq(2)$$

3.2 Monte Carlo Simulation

A major focus of this study was to understand how varying inputs/risk scenarios impacted expected outcomes by way of sensitivity analysis. The approach chosen to conduct sensitivity analysis was Monte Carlo Simulation (MCS) via @Risk software distributed by Lumivero. MSC is an iterative method that uses repeated random sampling to model the probability of different outcomes when there is uncertainty present in one or more input variables. MCS is commonly used in finance and economics to evaluate risk and uncertainty as it pertains to variation in input costs and the effects on financial feasibility. Instead of having only static inputs, producing a deterministic output, MCS is considered a stochastic model because it provides a range of possible outcomes, and their respective likelihood of occurrence present via a probability distribution function. With MCS it is easier to predict how fluctuations in input costs influence the annual practice costs and break-even scenarios for each practice or combination of practices.

The @Risk extension in Excel has six different options for probability distribution functions; Binomial, Normal, Pert, Triang, Uniform and Vary. For the purposes of this study the Pert distribution is

used for dynamic input variables as it uses beta distribution with three input parameter values: a minimum, most likely, and maximum value. This distribution function is a good solution when there is limited information on the exact values within a range, but the end bounds and most common values are well documented. It uses the three input parameters to create a continuous distribution function. The Pert distribution is more commonly used in cost analysis compared to the other distribution functions and is thus another motivator for application within this study. In this case, the values approved for the budget sheet were used as the ‘most likely’ value and the minimum and maximum values were a 20 percent reduction and increase from the base ‘most likely’ value to show a conservative possible range of input price variations.

Pert Distribution Function:

$$\mu = \frac{\sigma + 4\beta + \rho}{6}$$

σ = *minimum value*

β = *most likely value*

ρ = *maximum value*

The Pert DF applies a weighted average on the most likely value.

Within each budget sheet, I made specific inputs dynamic within the MCS. For every practice, any input cost, total exceeding \$50, when amortized over its useful life, was considered dynamic (will vary). This resulted in five dynamic variables for turbo fladry (flagged poly wire, electric fence charger, fiberglass posts, and both installation and maintenance labor), six dynamic variables for electrified night penning (maintenance labor, netting, training labor, solar panel, fence charger, and solar panel battery), five dynamic variables for range riding (range rider labor, truck use, horse use, trailer mileage, and cell phone/GPS), eleven dynamic variables for carcass composting (front-end loader, bulking agent, maintenance labor, well installation, pick-up truck use, jersey barriers, electric fence, concrete pad,

installation labor, sprinklers, and site lease fee), and six dynamic variables for LGD (dog food, vaccinations, training labor, cost of dog, insurance and shelter). The only exception to this rule was a \$200 yearly miscellaneous input cost that wasn't made dynamic for the LGD budget.

For the simulated cost benefit scenarios of predated livestock, there was an assumed cattle base FMV of \$2,000 and a sheep base FMV of \$200. As addressed earlier, depending on the characteristics of the livestock animal, the market cost can vary. However, for the purposes of this study I based these values on similar compensation payouts seen from other state programs. Colorado for example, has an average "calf" payout of \$1,646 and average "cattle" payout per confirmed animal of \$1,831, however multiple payments have exceeded \$2,000, reaching \$3,000 as can be found on CPW's website (Colorado Parks and Wildlife, 2024). Similarly, 2025 records from Montana's livestock loss board show that cattle are typically paid out in amounts ranging from \$1,600 to \$2,200 per head (Montana Department of Livestock, 2025).

Indemnification payouts disaggregated by head of sheep are more challenging to find, thus the \$200/head used in the simulation scenarios was based upon Montana's livestock auction reports discussed in the introduction section (U.S. Department of Agriculture - Agricultural Marketing Service, 2025).

Beyond the direct costs associated with livestock depredation, the simulated cost benefit scenarios also include indirect costs as often a predation occurrence has associated costs incurred via decreases in dressing weight as well as decreases in milk production and conception rates. For example, a study from 2014 found that calves were on average 22 lbs. lighter on ranches with a confirmed predation event than calves on ranches where there had been no predation (Ramler et al., 2014). Another study by Oakleaf (2003) found that for every animal found predated, there could be up to 7 more that are unfound. Steele et al. (2013) used stochastic budgets to analyze economic impacts of wolf predation. They found that the financial impacts from indirect effects may be as large as or larger than the direct effects. In a similar vein, a study that surveyed livestock producers about challenges related to wolf predation found that approximately 75% of respondents believed that indirect losses caused from predator-induced stress were

as, or more, financially damaging than the direct death of the livestock (Nickerson et al., 2024). To try to account for some of these secondary impacts, the simulated scenarios include an extra \$2,000 in indirect costs for a predated cattle animal as well as \$400 in indirect costs for a predated sheep.

Beyond the indirect and direct costs of a depredated livestock animal, the simulated scenarios also included a \$200/head transaction fee to account for extra time and equipment needed to preserve or manage a carcass. The hypothetical scenarios in the results section will account for possible multi-livestock predation occurrences. In those cases, the market value of the livestock animal will be multiplied by the number of predated animals while the transaction cost of \$200 will be held constant. This is to not overstate the potentially incurred livestock transaction fees as they are likely to not increase at the same rate as predation.

The exact annualized costs for each practice were taken directly from their respective enterprise budget in Appendix A to be used in data analysis. The basic values are: \$2,204/mile for turbo fladry, \$662 for night penning 250 sheep, \$20,219 for 1 range rider with horse at 20 hr/wk for 6 months, \$281/hd for carcass removal and \$2,167 for a guardian dog. The only variation from the direct budget sheet occurred regarding range riding. The original range riding cost assumes 6 months of range riding for a herd size of 101 – 400 head, up to 25,000 acres managed by one range rider working 20 hours a week. However, real world experience has observed a range rider being shared amongst multiple nearby ranch operations (Colorado Parks and Wildlife, 2025 & Conservation Northwest, n.d.). Therefore, to more closely simulate cost across a single operation the budget scenario set for the simulation bumped the herd size up to 901+ head total, which increased cost from \$20,219.20 to \$29,461.60. This range riding labor was then assumed to be split across five operations which factored down to \$5,892.32 per operation. It will be the individual operation cost that is considered for each range riding metric analysis in the results section.

4 – Data Collection and Analysis

4.1 Decision Aid Tool Steps

The data collection process for this project is respondent-driven, using individualized inputs from the decision aid tool's user to output results tailored to the livestock owner's inputs. To detail the specific process for data collection, it is most advantageous to outline each step of the decision aid tool, where there are 6 steps. It is important to note that the decision aid tool is not yet open to the public, so the data analysis in the results section is based on simulated scenarios of possible inputs.

Step 1: Select a location

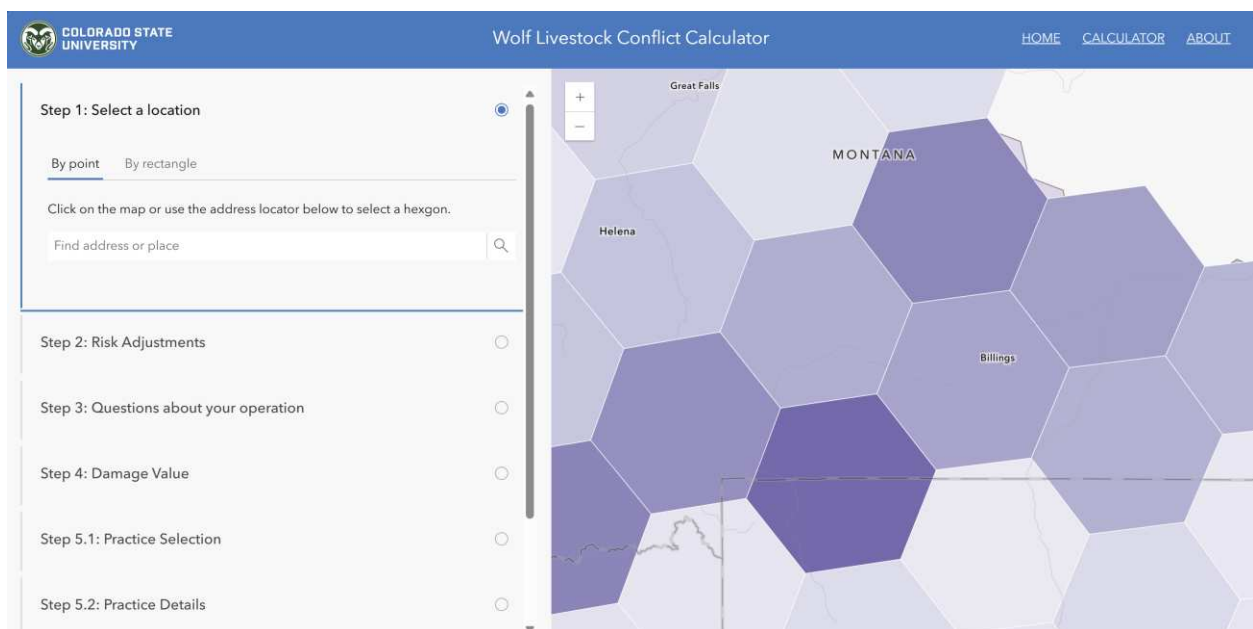


Figure 4.1 – Wolf Predation App Step 1

The user must first select the location of their operation within the US. Conflicts are estimated within 10km^2 hexagons. Hexagons are used because they reduce sampling bias due to their low perimeter-to-

area ratio. Additionally, any point inside a hexagon is closer to the centroid compared to a point in an equal-area square or triangle polygon (Environmental Systems Research Institute [accessed May 15, 2025]). The user can indicate their location either by clicking within the hexagon they reside, or by entering their address into the search bar. From there they will be presented with a risk probability of conflict. The process to retrieve a risk probability of conflict for a specific region is achieved via Maximum Entropy (MaxEnt), a species distribution modeling approach.

For this step in the decision aid, I used the probability of wolf-livestock conflict output retrieved from MaxEnt modeling with several spatial data layers in ArcGIS to output a probability of wolf-livestock conflict within the contiguous US.

The risk probability model employs 2,474 recorded predation conflicts in Washington, Arizona, New Mexico, Minnesota, and Wisconsin as well as an additional 17 incident reports recorded in Idaho and Montana. These data were collected from state fish and wildlife agencies as well as the USDA over the years 2002-2023. The level of detail in the report records varied across data providers and time and thus did not always include the severity of predation (i.e., injury or killed) or number of animals involved. Regardless of the number of animals involved, all occurrence records were treated as a single incident. When severity was reported, most reports indicated predation resulting in death; however, given the inconsistency of severity reporting, the occurrence records are considered as conflicts.

A spatial resolution of 1 km² was applied to match the scale of the environmental predictors and the ecological relevance of the study species. A 1 km x 1 km fishnet grid was generated to serve as a reference for both background point allocation and spatial thinning procedures. To mitigate sampling bias, a spatial thinning algorithm based on nearest-neighbor distance was executed retaining only one presence point within each 1 km grid cell. This approach helps reduce sampling bias and overfitting in species distribution models (Aiello-Lammens et al., 2015). In a similar process, to ensure independence between presence and background data, all background points located within 1 km of any presence location were removed.

The model takes into account a total of 15 explanatory variables, five being topographic variables (elevation, slope, aspect, terrain ruggedness, and distance to water), two explanatory variables being anthropogenic (distance to roads and a composite index of human modifications to the landscape), four variables being landscape (land cover type, land cover variety, canopy cover, and canopy cover variety), and four being food source variables (cattle density, elk density, mule-deer density, and white-tailed deer density).

MaxEnt chooses the distribution that maximizes the similarity between the environmental characteristics of the total environment and those of the locations where wolf conflicts were reported. A Receiver Operating Characteristic (ROC) curve is the most typical metric to evaluate the performance of a MaxEnt model in distinguishing between presence and absence locations for species distribution (true versus false positives). An Area Under Curve (AUC) represents a scalar summary of the ROC score and fits in a range of 0 to 1 with a score of 1 representing perfect discrimination and a score of 0.5 indicating random discrimination. The AUC for this model was 0.797 which indicates that the model has good predictive performance in distinguishing between true and false positives for wolf conflicts. The MaxEnt modeling for this research was originally developed by Dr. Kevin Butler/ESRI and later revised by Dr. Reza Goljani Amirkhiz /UCSC. While the two contributors worked independently, both efforts were instrumental in producing the resulting conflict risk modeling that is incorporated into the economic framework developed for this work.

Step 2: Risk Adjustments

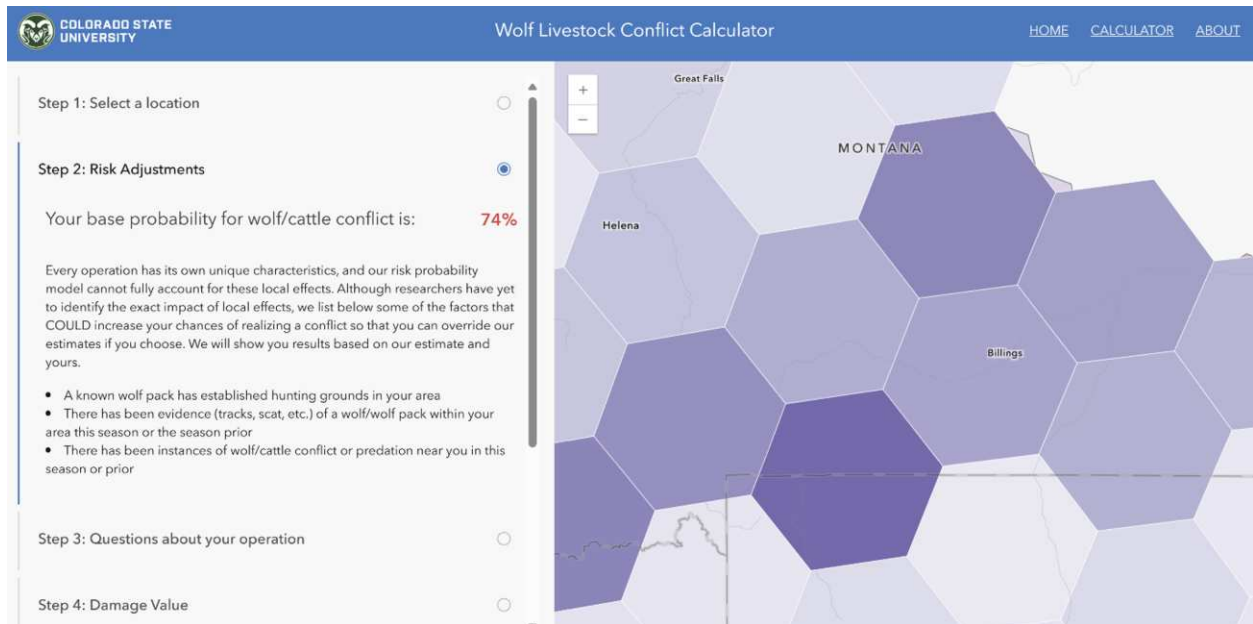


Figure 4.2 – Wolf Predation App Step 2

After a user identifies their location on the map, they receive a percent likelihood that one wolf-livestock conflict incident will occur. Every operation has its own unique characteristics. This risk probability can only do its best to account for these local effects. Some factors that could potentially increase a producer's chances of realizing a conflict are if a known wolf pack has established hunting grounds in their area, there has been evidence (tracks, scat, etc.) of a wolf/wolf pack within their area this season or the season prior and/or if there has been instances of wolf/cattle conflict or predation near them in the current or prior grazing season. A producer can leave the conflict probability score as is or if they feel their area is more at risk for livestock predation, they may choose to alter their score. If a producer feels that their base probability does not represent their operation, step 2 allows them to alter it.

Step 3: Questions about your operation

Step 3: Questions about your operation

Please enter the estimated size for each of the following livestock:

Approximately how many calves are present in your herd?

Approximately how many lambs are present in your flock?

Approximately how many yearlings are present in your herd?

Approximately how many ewes are present in your flock?

Approximately how many cows are present in your herd?

Approximately how many

Figure 4.3 – Wolf Predation App Step 3

Younger/smaller livestock are typically more susceptible to wolf predation; hence, this step asks producers to estimate the composition of their vulnerable livestock so it can be factored into the likelihood of the livestock animal that might be depredated. Understanding the herd composition of the vulnerable population is important as it significantly influences the potential monetary loss from wolf predation. This information ultimately factors into eq(2) from the methods section. Further explanation of this calculation can be found in step 4.

Step 4: Damage value

Step 4: Damage Value

We recognize that value of your livestock varies by operation. In addition, the cost to handle livestock killed by wolves varies from one producer to the next.

We apply a formula to compute a weighted average for one animal being killed based your answers below. Tell us, for cattle only or sheep only, if one of the following were to be killed by a wolf/wolves, how much lost income including costs associated with carcass removal/handling would be incurred. Indicate the market value you lost and the costs to handle the carcass and file for assistance if pursued.

Livestock	Net Market Value	Handling Costs
calves	2100 \$	200 \$
lambs	0 \$	0 \$
yearlings	2600 \$	200 \$
ewes	0 \$	0 \$
cows	2400 \$	200 \$
rams	0 \$	0 \$

Figure 4.4 – Wolf Predation App Step 4

Step 4 includes two input columns: one for the direct market value of the animal and another for handling or transaction costs associated with a depredated carcass. In this step, the producer can enter the estimated market value of their sheep or cattle broken down by sex and maturity. Producers are typically the most knowledgeable about the attributes that influence the final market price of their livestock. Additionally, this step permits producers to enter in costs associated with time and other material items used for carcass handling and management, whether the producer opts to preserve a carcass for investigation or promptly dispose of the carcass.

This step ties in with step 3 to calculate a weighted average PLI. A simplistic example would be if a cattle producer has 50 cows with an average FMV of \$2,400/head, 20 yearlings with an average FMV of \$1,800/head, and 30 calves with an average FMV of \$2,100/head the weighted average PLI would equate to \$2,190/head. This value would be the input for P in eq(2). The same process would occur for the handling costs and would be computed to determine the input for T in eq(2).

Example: $(0.5 * 2,400) + (0.2 * 1,800) + (0.3 * 2,100) = \$2,190$

While there may exist concerns, producers could be incentivized to falsely inflate their incurred costs, the purpose of this tool is to provide producers with a baseline understanding of their expected monetary gains or losses from practice implementation in comparison to their risk. Therefore, the accuracy of the tool’s output relies on the accuracy of the producer’s input responses.

Step 5.1: Practice Selection

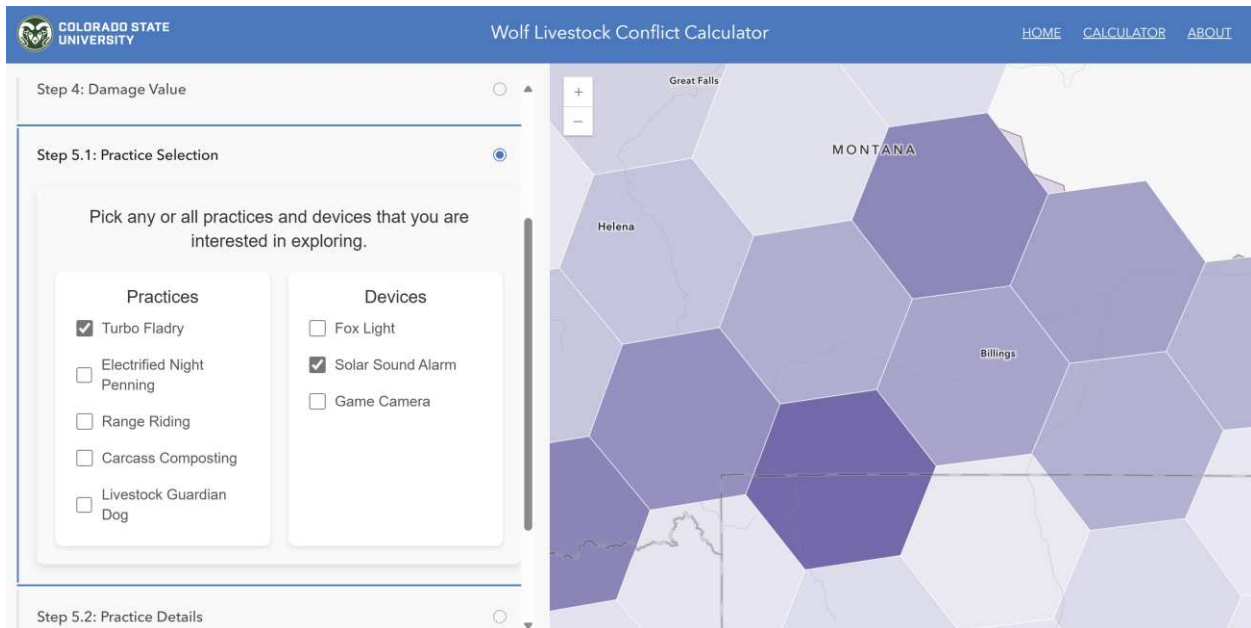


Figure 4.5 – Wolf Predation App Step 5.1

There are five mitigation practices included in this decision aid tool and three deterrent devices. The five practices are turbo fladry, electrified night penning, range riding, carcass composting and livestock guardian dogs, while the three deterrent devices are fox lights, sound alarms, and game cameras. Step 5.1 allows the user to indicate which practice(s) and/or device(s) they are interested in. The user is not limited in their selection and can choose anywhere from one to all eight devices and practices. The definitions for the following practices and items are below:

Practices:

Turbo fladry: A practice that employs a string of bright red or orange nylon flags that are incorporated into a hot wire for fencing. Wolves are considered neophobic animals, which means they fear things that are unfamiliar. The waving of the bright flags in the wind discourages wolves from approaching livestock. For turbo fladry to remain effective and wolves to not become habituated to the flagging, experts maintain that fladry should not be in use for more than a couple of months. Therefore, ranchers are recommended to utilize the fladry during calving and lambing season where livestock are most vulnerable and face their highest risk of predation.

Electrified Night Penning: A practice where livestock can be kept in a secure location surrounded by electrified fencing during the night when predation is most likely to occur. This practice can be used in conjunction with other practices such as fox lights, sound alarms or livestock guardian dogs. This practice can also be used during times where livestock is more at risk of predation such as calving and lambing season.

Range Riding: A predator/livestock conflict reduction tool that employs skilled laborers to monitor livestock and predators and to reduce interactions. Range riding essentially increases human presence on rural rangelands by implementing consistent monitoring of predator presence such as physical sitings, track, scat, as well as monitoring herd health. Range riders can be current ranch operation owners or employees, or they can be contracted out from federal and state wildlife programs and other NGOs. Range riding typically spans 6 months to cover the cattle grazing season from the beginning of May to the end of October; however, this may alter slightly depending on the region.

Carcass Composting: A practice that involves separating a deceased carcass or bone pile from an active ranching operation and properly decomposing the remains so that they can be reused for fertilizer or further carcass composting. Cattle carcasses as well as aged bone piles can act as an attractant for

predators such as wolves. Thus, relocating carcasses to off-site centralized facilities can help in limiting the presence of wolves.

Livestock Guardian Dogs: The presence of LGDs is a livestock-predator conflict reduction measure that utilizes large dog breeds that have historically been bred to protect domesticated animals such as livestock. Unlike pet dogs, LGDs usually are bonded and cohabitate with their livestock acting as a full-fledged member of the flock or herd. These dogs serve as an extra layer of protection to livestock by conducting perimeter patrols, marking territory, barking/alerting and fighting or chasing predators.

Step 5.2: Practice Details

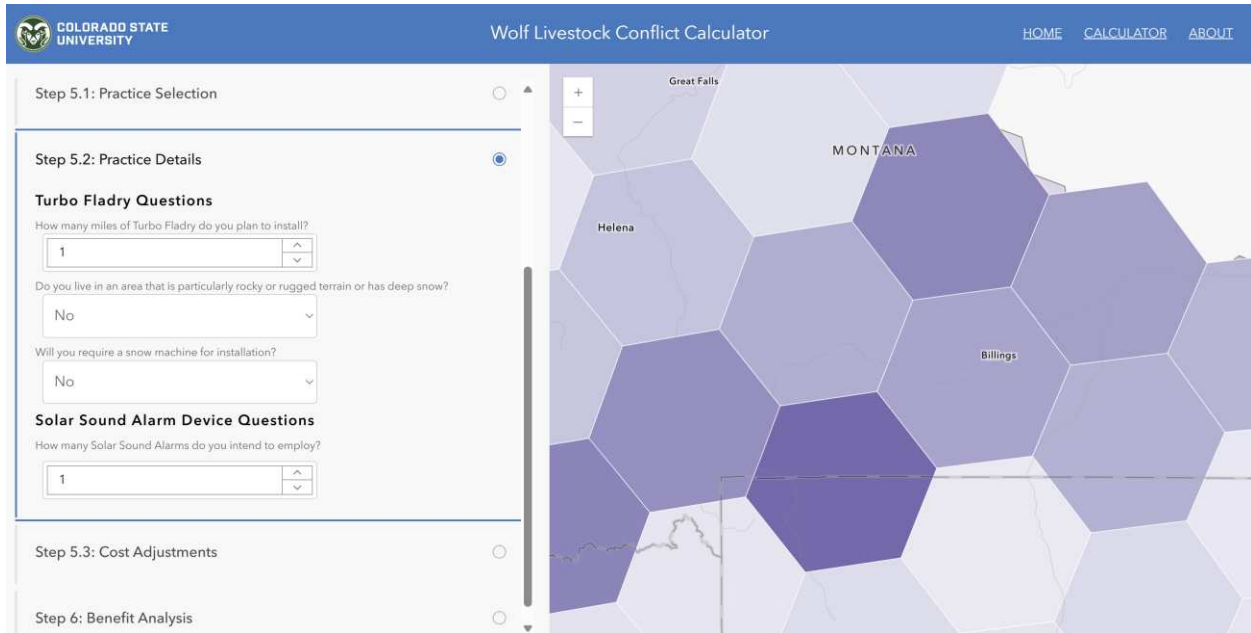


Figure 4.6 – Wolf Predation App Step 5.2

After a user indicates which practice(s)/device(s) they're interested in, Step 5.2 provides the user with questions tailored to the practice(s) that the user indicated interest in on the previous step. The questions ask the user specifics on their requirements for the practice to better estimate costs such as required feet for fencing, length of time for practice employment to gauge labor requirements, terrain ruggedness, etc. These question replies act as inputs for the practice budget sheets so that the annualized cost of the practice is modified for the individual user. Since the deterrent devices are individual items,

they don't have separate budget sheets and will instead be accounted for by amortizing their current market value over their useful life.

Step 6: Cost Adjustments

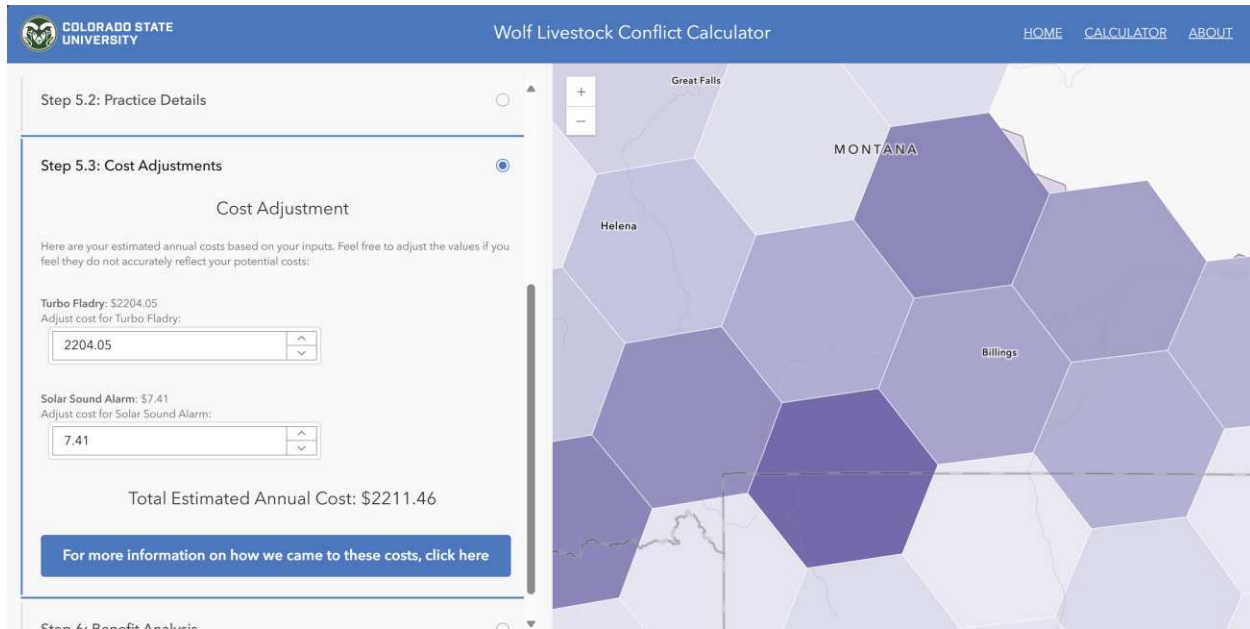


Figure 4.7 – Wolf Predation App Step 5.3

The budget sheets found in the Appendix for each practice serve as standard cost estimates; however, site-specific factors may affect actual expenses and cause the annualized practice cost to be higher or lower. For example, sizes and costs may be very different, or a producer may utilize used materials already on hand, or not wish to charge his/her own labor. This step provides producers with the opportunity to manually adjust their calculated annualized cost if they believe it does not accurately reflect their operation.

Step 7: Price Results

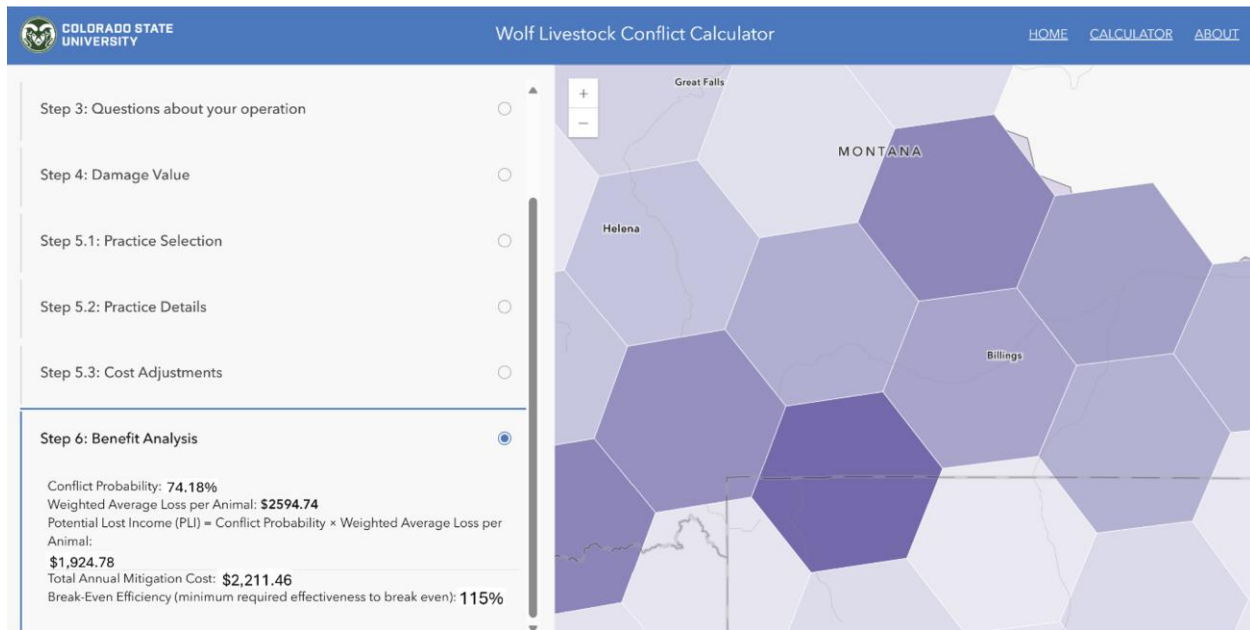


Figure 4.8 – Wolf Predation App Step 6

After any necessary cost adjustments are made, step 7 reveals a comparative break-even analysis between the PLI from the market and transaction costs associated with livestock predation and the cost of implementing the practice(s) and/or device(s) indicated by the user in step 5.1. The output results will show the user the combined practice efficiency necessary to break even. Additionally, a sensitivity table will show the user how increasing levels of practice efficiency and practice subsidy affect their break-even potential.

4.2 Enterprise Budget Creation

A key piece of the creation of the decision aid tool was the compilation and construction of respective enterprise budgets for the implementation and associated labor cost of each mitigation practice. A published supporting document detailing the process and supporting links used to build each respective budget sheet can be found in Appendix A. Each budget utilizes a “useful life” for relevant input items to account for material that can be reused from year to year. This allows the budgets to more accurately value annualized cost. The process to annualize these costs is amortization where a lump sum value is

evenly dispensed into yearly amounts based on the item's useful life, the interest rate and the original present value. These budgets assume a standard interest rate of 4%. Appendix A details the enterprise budget sheet creation process and following assumptions.

Each mitigation practice budget was peer reviewed by professionals who have direct experience in implementing and funding these practices either through employment in a community-based non-profit, membership-based organization or direct utilization in their personal operation. Our expert reviewers for the practices' enterprise budget sheets were Seth Wilson, the Executive director for the Montana Blackfoot Challenge, Matt Collins, the Working Wild Challenge Coordinator for the Western Landowners Alliance and Cameron Krebs an Oregon livestock producer.

5 – Results and Discussion

Assumptions:

In the on-line tool, annualized costs for the enterprise budget sheets are tailored to the operation specific questions such as size or prices provided to users. Responses to input questions in the tool are automatically transferred to enterprise budget sheets for scenario analyses. The document containing the budget sheets and their accompanying sources and assumptions can be found in Appendix A.

5.1 Break-Even Sensitivity Across Practices

To demonstrate potential financial outcomes, a variety of scenarios for each practice were simulated to provide insight into the practicality of practice implementation in terms of ability to break even between PLI and practice cost. For each practice I display results in sensitivity tables as they provide a robust way to measure the risk and uncertainty involved in practice viability. The column input variable

in the sensitivity tables' is practice efficiency percentage in increments of 5 percent, and the row input variable is risk of predation percentage in increments of 10 percent.

To focus on scenarios where practice implementation might be more viable, practice efficacy levels start at 50% and risk of predation levels also start at 50%. One way of interpreting the graph would be for example, in Table 5.1, looking at financial loss and gain for turbo fladry implementation. An 80% risk of a conflict and practice efficiency of 80% for example would cut that risk in half to 40 percent. The table has conditional formatting so that positive values are highlighted with green and negative values are highlighted in red.

An example for table interpretation can be found in Figure 5.1, under the presence of 50% predation risk and 80% turbo fladry practice efficiency and no practice subsidy, the producer incurs a net loss of \$524.05. However, within that same table, still at 80% practice efficiency and an increased predation risk of 80%, a producer realizes a financial gain of \$483.96 of implementing turbo fladry under this study's cost and FMV assumptions. This suggests under the latter specified parameters, that the annual cost to implement turbo fladry (with the input parameters set in this example) is \$483.96 less than the projected PLI associated with a single cattle predation and its included indirect costs.

As expected, for all five mitigation practices' sensitivity analyses, a higher risk of wolf-livestock conflict resulted in more possible net positive financial outcomes as the likelihood for offsetting PLI income is greater (Figure 5.2-5.5). These analyses are based on the assumption of one head of cattle livestock loss with a FMV of \$2,000, associated indirect costs of \$2,000 and a transaction cost of \$200 for turbo fladry, range riding, carcass composting and the livestock guardian dog practices and one sheep livestock loss of \$200, indirect costs of \$400 and a transaction cost of \$200 for the night penning practice.

Producers tend to experience financial gains when faced with a simultaneously high risk of conflict as well as relatively high practice efficiency. Table 5.2 for electrified night penning has positive financial gain only at very high levels of predation risk and practice efficiency (>80%). Notably Table 5.3

for range riding has no positive financial gains even with high risk and high practice efficacy when there is no practice subsidization. It is important to note here that these results are for the specific cost and value parameters set up for this study and outcomes could shift positively across more extensive scenarios. Adding more coverage for the rider or lower labor costs would increase the economic feasibility of a range rider.

It is important to properly interpret these break-even figures. First, lower values of risk and efficacy are ignored because it rarely pays to undertake prevention when both risk and efficacy are less than 50%. This may change for different underlying assumptions. Second, these break-even computations do not represent the actual amount of conflict or efficacy. They act as look-up tables for users that wish to determine feasibility based on their assumptions about their own risk and efficiency. The model of course gives them estimates that they may use, but all estimates should be validated to the extent possible in order for the model to provide accurate assessments. Lastly, the amount of positive or negative value squares in a figure does not indicate the value of a mitigation practice. The efficacy of each practice will vary for every location. The value of a practice compared to another will depend on what the user considers to be a representative efficacy, which is independent from the table.

Turbo Fladry Sensitivity Table (No Subsidy)							
Risk	1%	50%	60%	70%	80%	90%	100%
Practice Efficiency							
0%	-\$2,204.05	-\$2,204.05	-\$2,204.05	-\$2,204.05	-\$2,204.05	-\$2,204.05	-\$2,204.05
50%	-\$2,183.05	-\$1,154.05	-\$944.05	-\$734.05	-\$524.05	-\$314.05	-\$104.05
55%	-\$2,180.95	-\$1,049.05	-\$818.05	-\$587.05	-\$356.05	-\$125.05	\$105.95
60%	-\$2,178.85	-\$944.05	-\$692.05	-\$440.05	-\$188.05	\$63.95	\$315.95
65%	-\$2,176.75	-\$839.05	-\$566.05	-\$293.05	-\$20.05	\$252.95	\$525.95
70%	-\$2,174.65	-\$734.05	-\$440.05	-\$146.05	\$147.95	\$441.95	\$735.95
75%	-\$2,172.55	-\$629.05	-\$314.05	\$0.95	\$315.95	\$630.95	\$945.95
80%	-\$2,170.45	-\$524.05	-\$188.05	\$147.95	\$483.95	\$819.95	\$1,155.95
85%	-\$2,168.35	-\$419.05	-\$62.05	\$294.95	\$651.95	\$1,008.95	\$1,365.95
90%	-\$2,166.25	-\$314.05	\$63.95	\$441.95	\$819.95	\$1,197.95	\$1,575.95
95%	-\$2,164.15	-\$209.05	\$189.95	\$588.95	\$987.95	\$1,386.95	\$1,785.95
100%	-\$2,162.05	-\$104.05	\$315.95	\$735.95	\$1,155.95	\$1,575.95	\$1,995.95

Figure 5.1 – Turbo Fladry Sensitivity Table for Financial Loss/Gain under No Subsidy

Electrified Night Penning Sensitivity Table (No Subsidy)							
Risk	1%	50%	60%	70%	80%	90%	100%
Practice Efficiency							
0%	-\$619.93	-\$619.93	-\$619.93	-\$619.93	-\$619.93	-\$619.93	-\$619.93
50%	-\$615.93	-\$419.93	-\$379.93	-\$339.93	-\$299.93	-\$259.93	-\$219.93
55%	-\$615.53	-\$399.93	-\$355.93	-\$311.93	-\$267.93	-\$223.93	-\$179.93
60%	-\$615.13	-\$379.93	-\$331.93	-\$283.93	-\$235.93	-\$187.93	-\$139.93
65%	-\$614.73	-\$359.93	-\$307.93	-\$255.93	-\$203.93	-\$151.93	-\$99.93
70%	-\$614.33	-\$339.93	-\$283.93	-\$227.93	-\$171.93	-\$115.93	-\$59.93
75%	-\$613.93	-\$319.93	-\$259.93	-\$199.93	-\$139.93	-\$79.93	-\$19.93
80%	-\$613.53	-\$299.93	-\$235.93	-\$171.93	-\$107.93	-\$43.93	\$20.07
85%	-\$613.13	-\$279.93	-\$211.93	-\$143.93	-\$75.93	-\$7.93	\$60.07
90%	-\$612.73	-\$259.93	-\$187.93	-\$115.93	-\$43.93	\$28.07	\$100.07
95%	-\$612.33	-\$239.93	-\$163.93	-\$87.93	-\$11.93	\$64.07	\$140.07
100%	-\$611.93	-\$219.93	-\$139.93	-\$59.93	\$20.07	\$100.07	\$180.07

Figure 5.2 – Electrified Night Penning Sensitivity Table for Financial Loss/Gain under No Subsidy

Range Riding Sensitivity Table (No Subsidy)							
Risk	1%	50%	60%	70%	80%	90%	100%
Practice Efficiency							
0%	-\$5,892.32	-\$5,892.32	-\$5,892.32	-\$5,892.32	-\$5,892.32	-\$5,892.32	-\$5,892.32
50%	-\$5,871.32	-\$4,842.32	-\$4,632.32	-\$4,422.32	-\$4,212.32	-\$4,002.32	-\$3,792.32
55%	-\$5,869.22	-\$4,737.32	-\$4,506.32	-\$4,275.32	-\$4,044.32	-\$3,813.32	-\$3,582.32
60%	-\$5,867.12	-\$4,632.32	-\$4,380.32	-\$4,128.32	-\$3,876.32	-\$3,624.32	-\$3,372.32
65%	-\$5,865.02	-\$4,527.32	-\$4,254.32	-\$3,981.32	-\$3,708.32	-\$3,435.32	-\$3,162.32
70%	-\$5,862.92	-\$4,422.32	-\$4,128.32	-\$3,834.32	-\$3,540.32	-\$3,246.32	-\$2,952.32
75%	-\$5,860.82	-\$4,317.32	-\$4,002.32	-\$3,687.32	-\$3,372.32	-\$3,057.32	-\$2,742.32
80%	-\$5,858.72	-\$4,212.32	-\$3,876.32	-\$3,540.32	-\$3,204.32	-\$2,868.32	-\$2,532.32
85%	-\$5,856.62	-\$4,107.32	-\$3,750.32	-\$3,393.32	-\$3,036.32	-\$2,679.32	-\$2,322.32
90%	-\$5,854.52	-\$4,002.32	-\$3,624.32	-\$3,246.32	-\$2,868.32	-\$2,490.32	-\$2,112.32
95%	-\$5,852.42	-\$3,897.32	-\$3,498.32	-\$3,099.32	-\$2,700.32	-\$2,301.32	-\$1,902.32
100%	-\$5,850.32	-\$3,792.32	-\$3,372.32	-\$2,952.32	-\$2,532.32	-\$2,112.32	-\$1,692.32

Figure 5.3 – Range Riding Sensitivity Table for Financial Loss/Gain under No Subsidy

Carcass Composting Sensitivity Table (No Subsidy)							
Risk	1%	50%	60%	70%	80%	90%	100%
Practice Efficiency							
0%	-\$280.64	-\$280.64	-\$280.64	-\$280.64	-\$280.64	-\$280.64	-\$280.64
50%	-\$259.64	\$769.36	\$979.36	\$1,189.36	\$1,399.36	\$1,609.36	\$1,819.36
55%	-\$257.54	\$874.36	\$1,105.36	\$1,336.36	\$1,567.36	\$1,798.36	\$2,029.36
60%	-\$255.44	\$979.36	\$1,231.36	\$1,483.36	\$1,735.36	\$1,987.36	\$2,239.36
65%	-\$253.34	\$1,084.36	\$1,357.36	\$1,630.36	\$1,903.36	\$2,176.36	\$2,449.36
70%	-\$251.24	\$1,189.36	\$1,483.36	\$1,777.36	\$2,071.36	\$2,365.36	\$2,659.36
75%	-\$249.14	\$1,294.36	\$1,609.36	\$1,924.36	\$2,239.36	\$2,554.36	\$2,869.36
80%	-\$247.04	\$1,399.36	\$1,735.36	\$2,071.36	\$2,407.36	\$2,743.36	\$3,079.36
85%	-\$244.94	\$1,504.36	\$1,861.36	\$2,218.36	\$2,575.36	\$2,932.36	\$3,289.36
90%	-\$242.84	\$1,609.36	\$1,987.36	\$2,365.36	\$2,743.36	\$3,121.36	\$3,499.36
95%	-\$240.74	\$1,714.36	\$2,113.36	\$2,512.36	\$2,911.36	\$3,310.36	\$3,709.36
100%	-\$238.64	\$1,819.36	\$2,239.36	\$2,659.36	\$3,079.36	\$3,499.36	\$3,919.36

Figure 5.4 – Carcass Composting Sensitivity Table for Financial Loss/Gain under No Subsidy

Livestock Guardian Dog Sensitivity Table (No Subsidy)							
Risk	1%	50%	60%	70%	80%	90%	100%
Practice Efficiency							
0%	-\$2,464.18	-\$2,464.18	-\$2,464.18	-\$2,464.18	-\$2,464.18	-\$2,464.18	-\$2,464.18
50%	-\$2,443.18	-\$1,414.18	-\$1,204.18	-\$994.18	-\$784.18	-\$574.18	-\$364.18
55%	-\$2,441.08	-\$1,309.18	-\$1,078.18	-\$847.18	-\$616.18	-\$385.18	-\$154.18
60%	-\$2,438.98	-\$1,204.18	-\$952.18	-\$700.18	-\$448.18	-\$196.18	\$55.82
65%	-\$2,436.88	-\$1,099.18	-\$826.18	-\$553.18	-\$280.18	-\$7.18	\$265.82
70%	-\$2,434.78	-\$994.18	-\$700.18	-\$406.18	-\$112.18	\$181.82	\$475.82
75%	-\$2,432.68	-\$889.18	-\$574.18	-\$259.18	\$55.82	\$370.82	\$685.82
80%	-\$2,430.58	-\$784.18	-\$448.18	-\$112.18	\$223.82	\$559.82	\$895.82
85%	-\$2,428.48	-\$679.18	-\$322.18	\$34.82	\$391.82	\$748.82	\$1,105.82
90%	-\$2,426.38	-\$574.18	-\$196.18	\$181.82	\$559.82	\$937.82	\$1,315.82
95%	-\$2,424.28	-\$469.18	-\$70.18	\$328.82	\$727.82	\$1,126.82	\$1,525.82
100%	-\$2,422.18	-\$364.18	\$55.82	\$475.82	\$895.82	\$1,315.82	\$1,735.82

Figure 5.5 – Livestock Guardian Dog Sensitivity Table for Financial Loss/Gain under No Subsidy

5.2 Multiple Animal Predation

Figure 5.6 explores financial outcomes with increasing predation occurrences across practice types. This figure incorporates predation quantities on the vertical axis increasing by increments of one and risk probability on the horizontal axis increasing by increment of 10%. Rather than showing monetary values, Figure 5.6 tables (a) through (e) show practice efficiency requirements to break even. To display more realistic practice efficiency capabilities, Figure 5.6's tables have conditional formatting so that any efficiencies of 50% or less are highlighted green and efficiencies that are greater than 50% are highlighted red. In this case, the figures do not include indirect costs but rather a \$2,000 FMV for each predated cattle animal and a \$200 FMV for each sheep with a base transaction cost of \$200 for each type of livestock. An extra predation can be considered an actual expected extra predation (e.g. 2 instead of 1), but could also cover indirect costs such as undetected animals, pregnancy or weight stress loss, or predations from other predators such as coyotes that would be deterred by the wolf mitigation practices.

Figure 5.6 (a) indicates that turbo fladry is relatively cost effective under scenarios with multiple cattle predations. With no subsidy and one predation occurrence, turbo fladry reaches no break-even efficiencies that lay under 100% (a trend across all practices). However, under instances of two predated cattle with risk of predation being 70%, 80% and 90%, turbo fladry's required effectiveness to break even would need to be 75%, 66% and 55% respectively.

Figure 5.6 (b) indicates that night penning is almost never "profitable" when no subsidization is utilized unless there is a high probability that four or more sheep are depredated. For example, at instances where the risk of predation for four sheep is between 60-70%, electrified night penning would need to be approximately 90-100% effective. Figure 5.6 (c) for range riding denotes very similar trends to electrified night penning in that under scenarios of no subsidies even with multiple cattle predations, there is an extremely low chance of financial payoff from practice implementation.

Figure 5.6 (d) shows uniformly low break-even efficiency requirements for carcass composting. Figure 5.6 (e) illustrates that a LGD will break even under scenarios of high practice efficiency in combination with moderate to high risk of predation with two or more cattle predations. For instance, at an 80% risk that two cattle animals will be depredated under no subsidy support, one LGD would need to be 73% effective at mitigating wolf attacks.

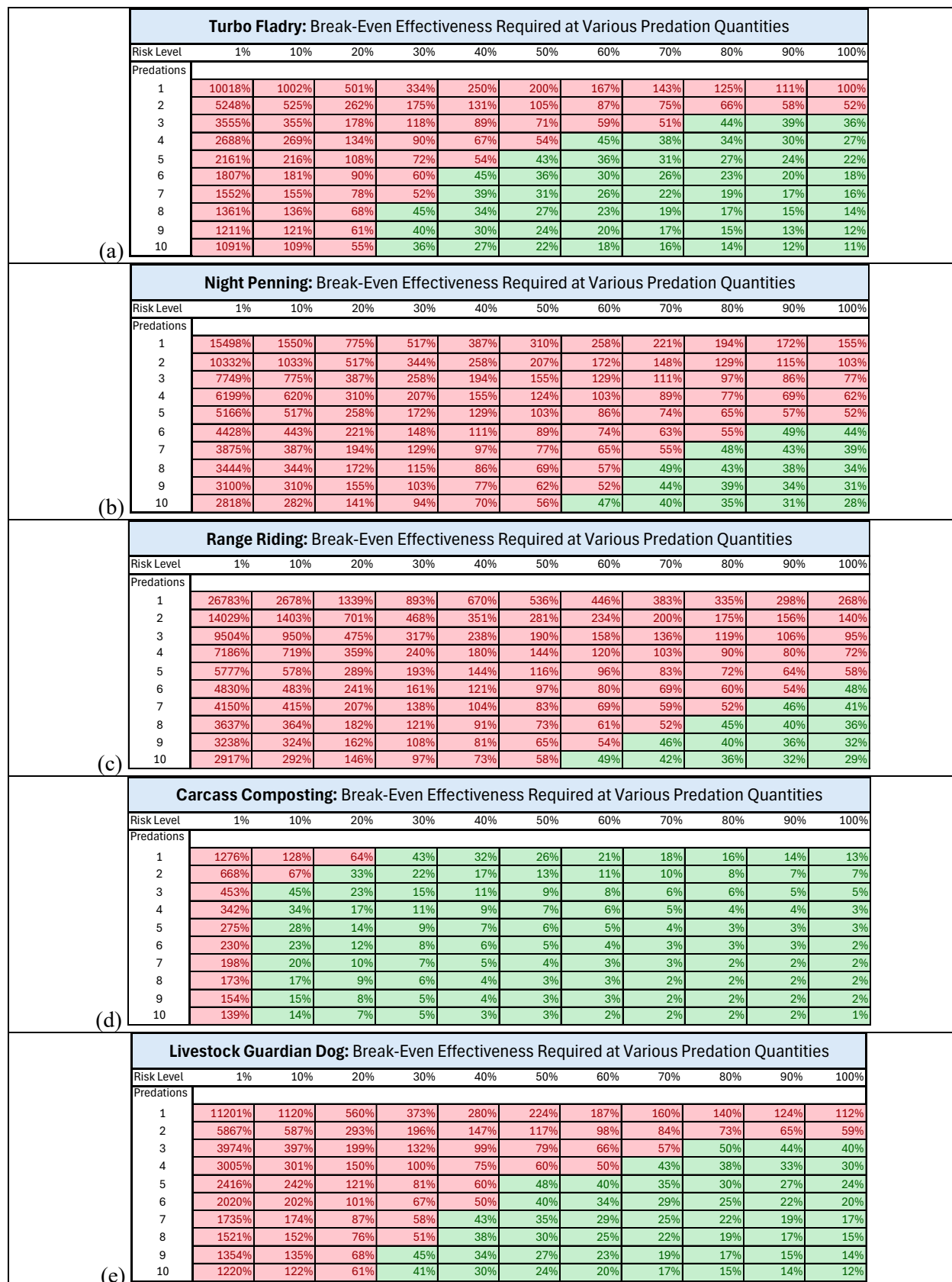


Figure 5.6 – Break-Even Effectiveness Required at Increasing Predation Quantities across Practice Types

5.3 Cost Uncertainty by Practice using Monte Carlo Simulation

The @risk PDF graph outputs shown in Figures 5.7 – 5.11 display the likelihood that each of the practices’ total cost will lay within a particular price range. Unsurprisingly, range riding has the highest overall cost of the five practices with 90% of the simulation’s 5,000 iterations falling between \$5,244 to \$6,538. The next most expensive practice is livestock guardian dog with 90% of its simulation’s iterations falling within \$2,308 to \$2,617; these ranges were \$2,052 to \$2,355 for turbo fladry, \$588 to \$653 for electrified night penning, and \$264 to \$295 for carcass composting. The distributions for all five practices—turbo fladry, night penning, range riding, and carcass composting—were nearly symmetrical, exhibiting minimal skewness ratings of -0.0283, 0.0614, 0.0049, -0.0238, and -0.0039, respectively. This symmetry is attributed to the Pert distribution assumptions where the high and low values used to generate the distributions were symmetrically set at +/- 20% around the median. Additionally, in the same order as previously noted, the practices had kurtosis values of, 2.5675, 2.7421, 2.3416, 2.7134, and 2.4825. These values indicate that all five distributions are slightly platykurtic, meaning they have few extreme outliers and overall broader peaks.

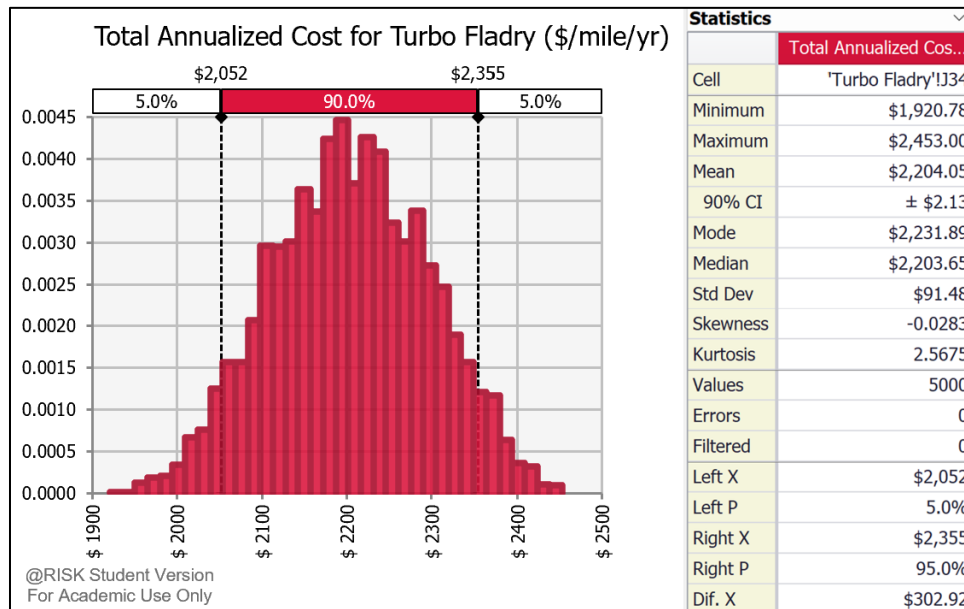


Figure 5.7 – PDF for Annualized Cost of Turbo Fladry

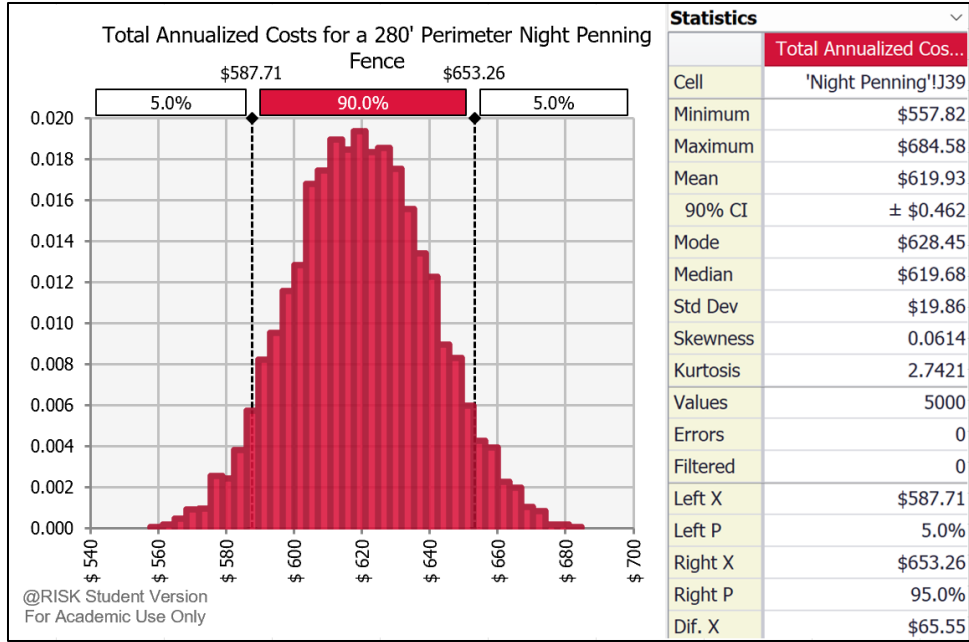


Figure 5.8 – PDF for Annualized Cost of Electrified Night Penning

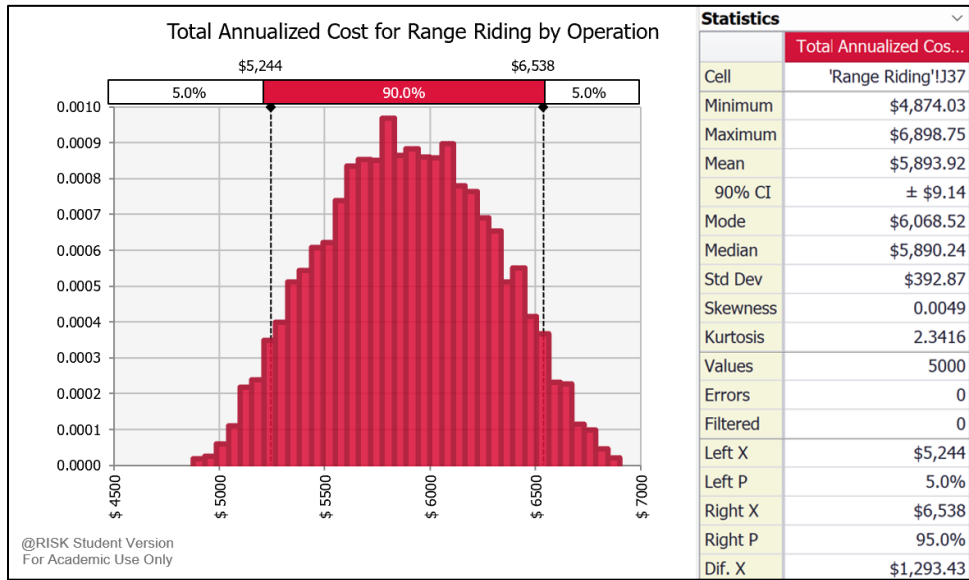


Figure 5.9 – PDF for Annualized Cost of Range Riding

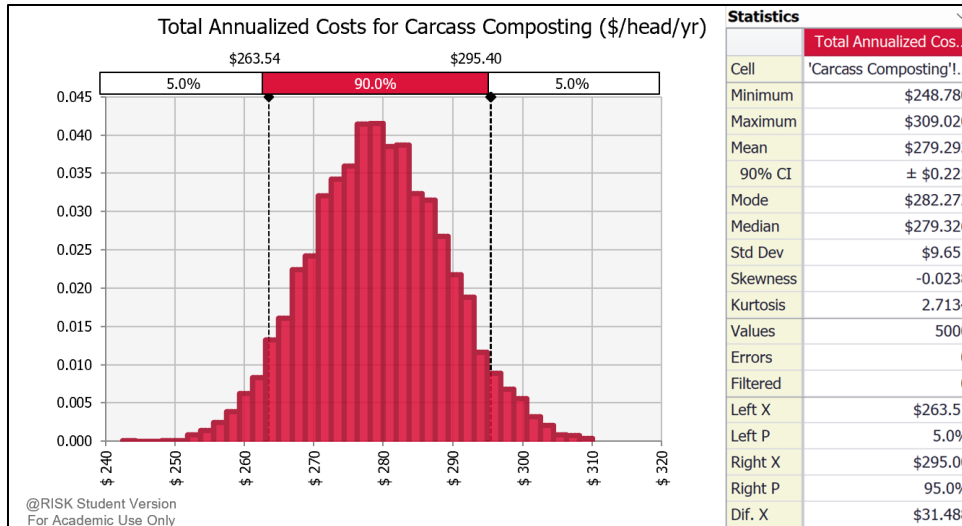


Figure 5.10 – PDF for Annualized Cost of Carcass Composting

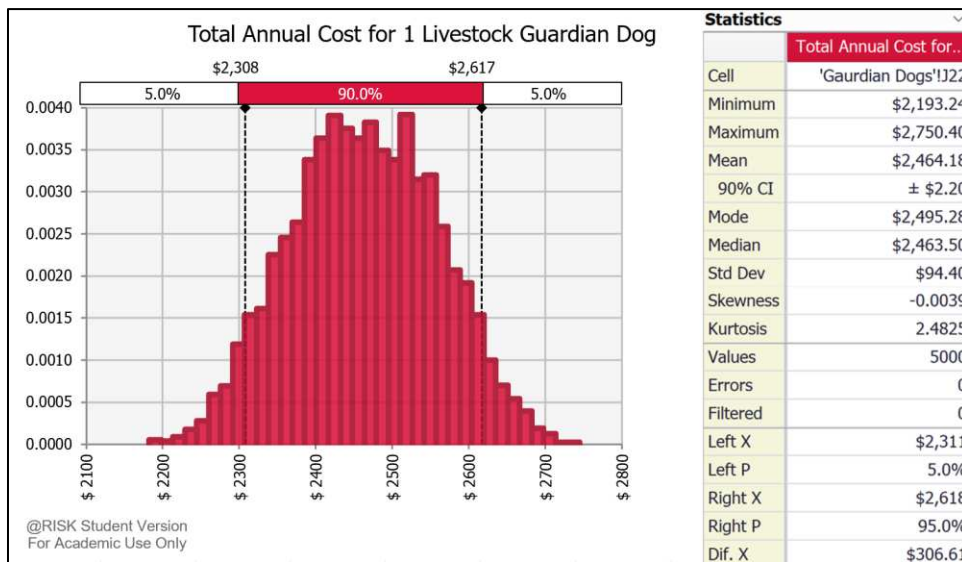


Figure 5.11 – PDF for Annualized Cost of a LGD

5.4 High Impact Variable Inputs

The distributions in Figures 5.7 to 5.11 show the range in cost that might occur when key inputs of each practice are varied up or down by 20%. A tornado graph is a visual tool used to show how sensitive a model's output is to changes in input values. In this context, the tornado charts shown in Figures 5.12-5.16 indicate how significant an impact independent material and labor inputs are on the final cost of each

mitigation practice. Each tornado graph ranks input variables from top to bottom, starting with the one that has the greatest impact on practice cost and ending with the one that has the least. The horizontal bars on each graph represent the range of possible outcomes when each input varies. Wider bars indicate a greater influence on cost. Each bar represents the isolated effect the dynamic variable has on the practices' cost. To do this, the variable of interest is isolated, allowing only that variable to change while excluding all others from the calculation. Each simulation runs 5,000 iterations to generate a range of costs.

The bars in the tornado graph represent the average total cost of a respective practice when the input is at the lowest and highest 10% of its 5,000 iterations. For example, in Figure 5.12, flagged polywire has the most impact on turbo fladry's overall cost. When the lowest 10% of flagged polywire cost iterations are considered, the mean total cost of the turbo fladry practice is \$2,070.59. When the highest 10 percent of flagged polywire cost iterations are considered, the mean total cost of the turbo fladry practice is \$2,339.38. Likewise, this process is calculated through the rest of the dynamic variables from maintenance labor down through the electric fence charger. The most impactful dynamic input for electrified night penning is maintenance labor with a lower mean output cost of \$599.64 and higher mean output cost of \$641.68. The range riding practice is unique because the majority of its cost comes from range rider labor. As can be seen in Figure 5.14, this input dominates the tornado graph. In this case, labor costs alone can shift the total from as low as \$5,229.36 to as high as \$6,558.90. Carcass composting's most impactful input is its use of the front-end loader with a lower mean practice cost of 266.78 and higher mean practice cost of \$292.26. The most impactful dynamic input for LGD is dog food with a lower mean practice cost of \$2,319.97 and higher mean practice cost of \$2,606.48.

Overall, the baseline for turbo fladry sits at \$2,204.05 but when considering the highest cost possibilities in every dynamic input, turbo fladry could cost as much as \$2,475.40 or 12.31% more than the stated baseline. Likewise, electrified night penning, range riding, carcass composting and LGD could cost 13.18%, 13.40%, 12.71% and 11.44% more due to the variability within their dynamic input costs.

Because the dynamic inputs for all the practices only varied 20% above and below their most likely value, it follows that all the max cost variances would trend similarly across practices.

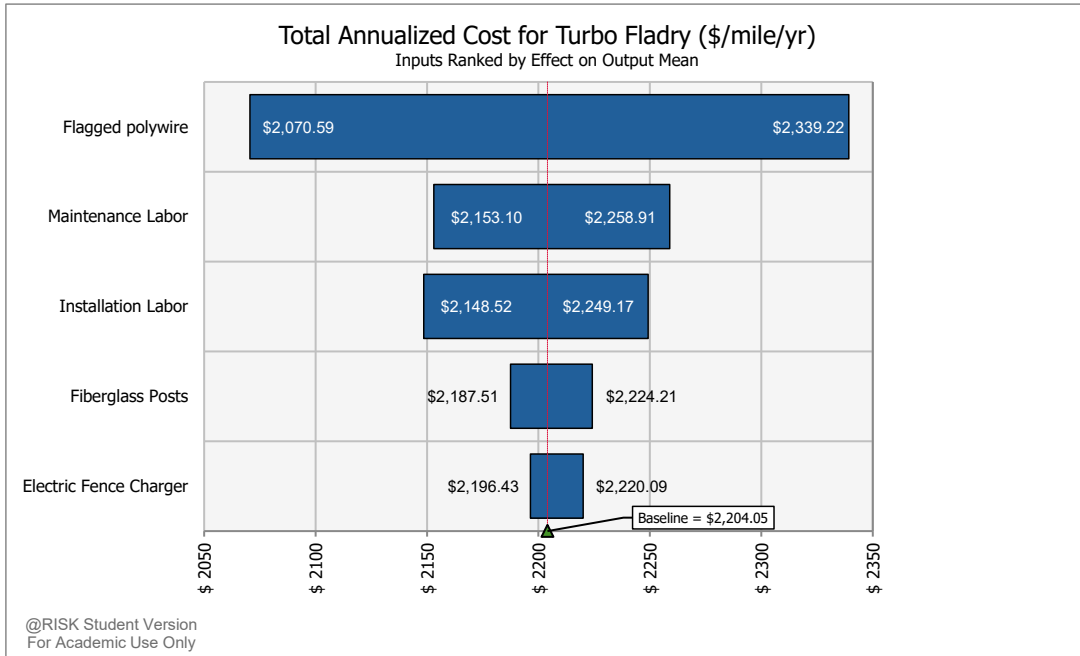


Figure 5.12 – Tornado Graph for Annualized Cost of Turbo Fladry

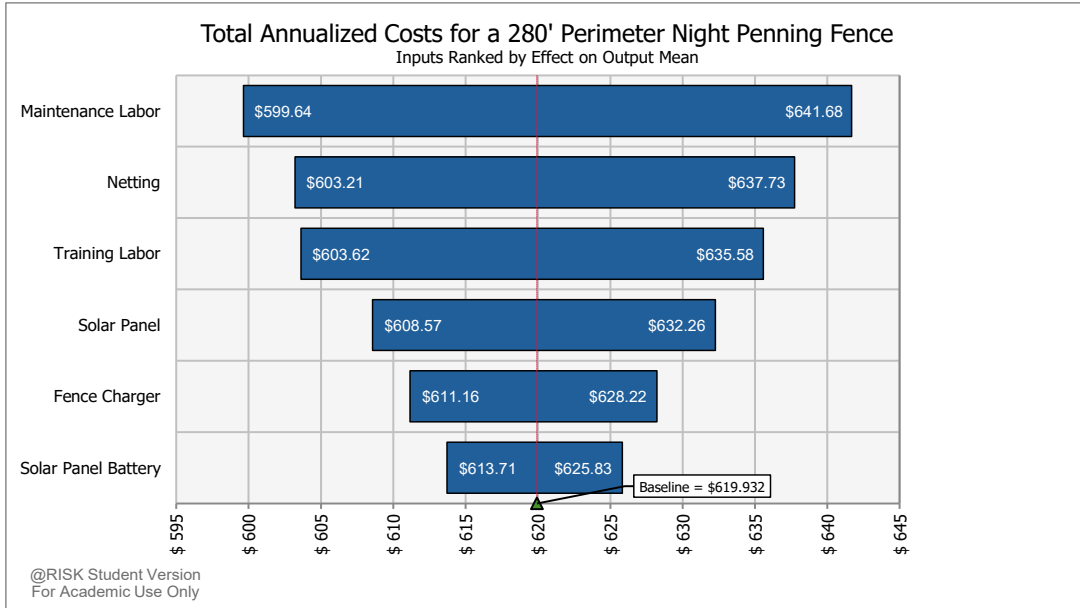


Figure 5.13 – Tornado Graph for Annualized Cost of Electrified Night Penning

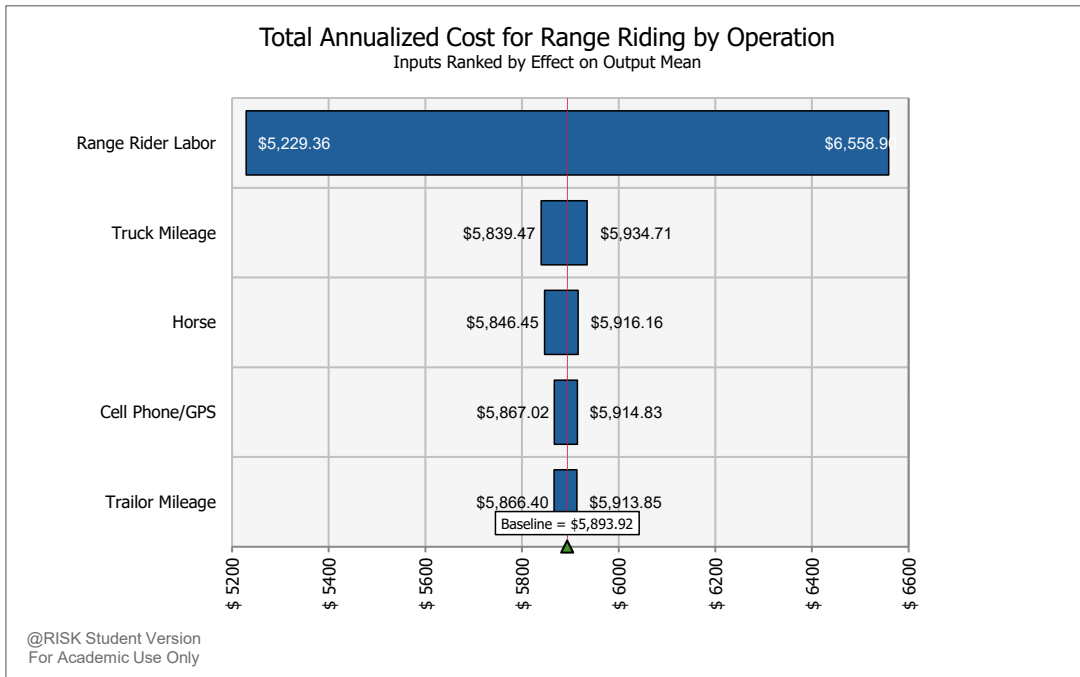


Figure 5.14 – Tornado Graph for Annualized Cost of Range Riding

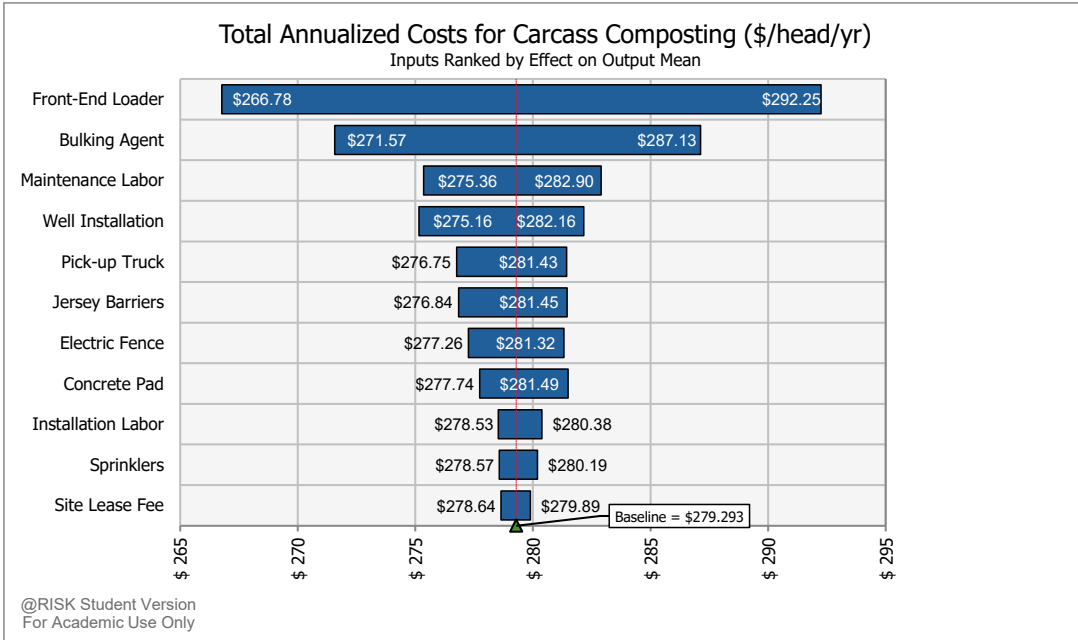


Figure 5.15 – Tornado Graph for Annualized Cost of Carcass Composting

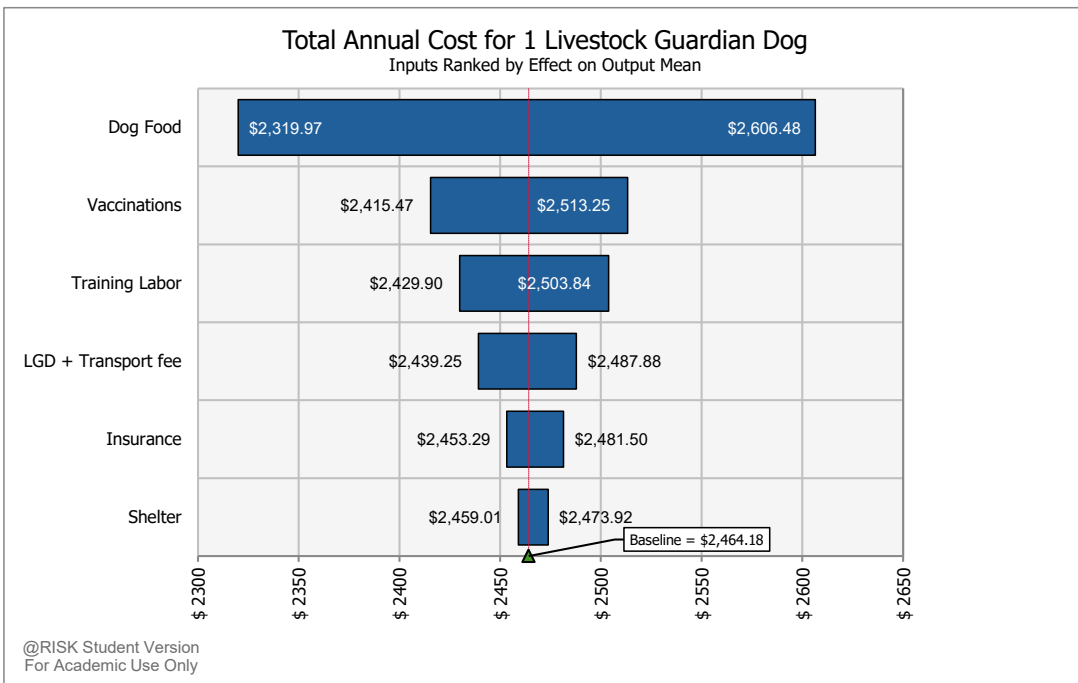


Figure 5.16 – Tornado Graph for Annualized Cost of a LGD

5.5 Implementation of Multiple Practices

There are multiple different combinations of practices a producer could choose to employ on their operation. The use of LGDs and electrified night penning are often used in tandem for protection of sheep and goats. Furthermore, carcass composting is likely to be used in combination with any of the other practices within this study. It can be assumed that proper installation and execution of two practices would increase overall efficiency or ability to deter wolves, but to what degree cannot be extrapolated with the available data and lays outside of the scope of this study. Nevertheless, sensitivity analysis can still be run with hypothetical combined efficiencies to gauge financial viability. In this case practice efficiency is assumed to be how effective the use of both practices are in conjunction at deterring wolf predation.

Figure 5.17 (a) consists of a sensitivity table showcasing the break-even outcomes of using electrified night penning and a LGD in combined use. Similarly, Figure 5.18 (a) reflects break-even scenarios for the combined use of carcass composting and turbo fladry in offsetting the PLI from a depredated cow.

Figure 5.17 (b) and Figure 5.18 (b) display break-even efficiency required of the combined practice scenarios under varying efficiency and risk of predation when there are multiple livestock predations occurring and no subsidy. As can be observed in Figure 5.17 (b), there is no situation (under this study's specifications) in which it is financially feasible for a producer to implement the combined use of night penning and the LGD unless the practice is partially or fully subsidized. However, Figure 5.18 (b) demonstrates that with the combined use of carcass composting and turbo fladry, there are possible scenarios where a producer can break even when there is the presence of a high practice efficiency and high risk of predation. When considering multiple livestock predations, specifically two predated cattle, break-even efficiency becomes possible at risk levels greater than 70%. When three cattle are predated break-even practice efficiencies become possible at risk levels of greater than 40%.

In summary, combining practices is presumed to increase efficiency but also cost. It will improve feasibility only if the efficacy rises by more than the costs, which was not the case for the examples I considered.

Combined Use of LGD and ENP							
Risk	1%	50%	60%	70%	80%	90%	100%
Practice Efficiency							
0%	-\$3,084.11	-\$3,084.11	-\$3,084.11	-\$3,084.11	-\$3,084.11	-\$3,084.11	-\$3,084.11
50%	-\$3,080.11	-\$2,884.11	-\$2,844.11	-\$2,804.11	-\$2,764.11	-\$2,724.11	-\$2,684.11
55%	-\$3,079.71	-\$2,864.11	-\$2,820.11	-\$2,776.11	-\$2,732.11	-\$2,688.11	-\$2,644.11
60%	-\$3,079.31	-\$2,844.11	-\$2,796.11	-\$2,748.11	-\$2,700.11	-\$2,652.11	-\$2,604.11
65%	-\$3,078.91	-\$2,824.11	-\$2,772.11	-\$2,720.11	-\$2,668.11	-\$2,616.11	-\$2,564.11
70%	-\$3,078.51	-\$2,804.11	-\$2,748.11	-\$2,692.11	-\$2,636.11	-\$2,580.11	-\$2,524.11
75%	-\$3,078.11	-\$2,784.11	-\$2,724.11	-\$2,664.11	-\$2,604.11	-\$2,544.11	-\$2,484.11
80%	-\$3,077.71	-\$2,764.11	-\$2,700.11	-\$2,636.11	-\$2,572.11	-\$2,508.11	-\$2,444.11
85%	-\$3,077.31	-\$2,744.11	-\$2,676.11	-\$2,608.11	-\$2,540.11	-\$2,472.11	-\$2,404.11
90%	-\$3,076.91	-\$2,724.11	-\$2,652.11	-\$2,580.11	-\$2,508.11	-\$2,436.11	-\$2,364.11
95%	-\$3,076.51	-\$2,704.11	-\$2,628.11	-\$2,552.11	-\$2,476.11	-\$2,400.11	-\$2,324.11
100%	-\$3,076.11	-\$2,684.11	-\$2,604.11	-\$2,524.11	-\$2,444.11	-\$2,364.11	-\$2,284.11

(a)

Electrified Night Penning and LGD: Break-Even Effectiveness Required at Various Sheep Predation Quantities											
Risk Level	1%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Predations											
1	77103%	7710%	3855%	2570%	1928%	1542%	1285%	1101%	964%	857%	771%
2	51402%	5140%	2570%	1713%	1285%	1028%	857%	734%	643%	571%	514%
3	38551%	3855%	1928%	1285%	964%	771%	643%	551%	482%	428%	386%
4	30841%	3084%	1542%	1028%	771%	617%	514%	441%	386%	343%	308%
5	25701%	2570%	1285%	857%	643%	514%	428%	367%	321%	286%	257%
6	22029%	2203%	1101%	734%	551%	441%	367%	315%	275%	245%	220%
7	19276%	1928%	964%	643%	482%	386%	321%	275%	241%	214%	193%
8	17134%	1713%	857%	571%	428%	343%	286%	245%	214%	190%	171%
9	15421%	1542%	771%	514%	386%	308%	257%	220%	193%	171%	154%
10	14019%	1402%	701%	467%	350%	280%	234%	200%	175%	156%	140%

(b)

Figure 5.17 – Sensitivity Analysis for Combination of Electrified Night Penning and LGD

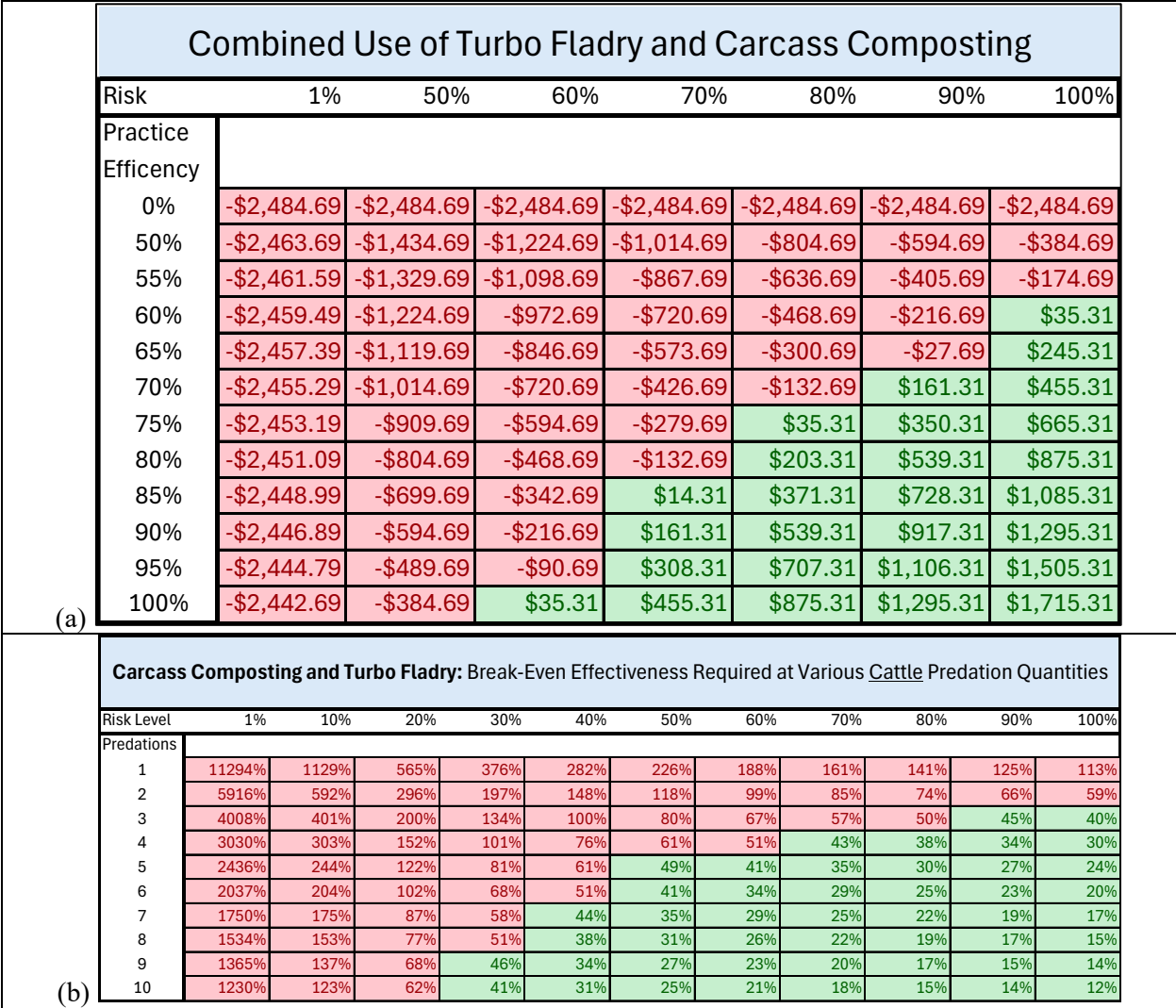


Figure 5.18 – Sensitivity Analysis for Combination of Carcass Composting and Turbo Fladry

5.6 Subsidies and Livestock Loss Compensation

Ultimately there are two main avenues in which money is distributed to a producer in relation to wolf predation. The first is via practice subsidization and the second way is via direct compensation of livestock loss after a confirmed wolf kill. A producer can receive one or the other, both or neither of these types of payments. These two mechanisms create different financial incentives, which are explored in Figure 5.19, focusing on how producer payments influence the financial viability of implementing predation prevention practices. Since the trends remain consistent across all five practices, Figure 5.19

adopts the same framework as the sensitivity graph in Figure 5.1, for turbo fladry, except it incorporates lower bounds of practice efficiency and risk level.

To illustrate general subsidy trends, turbo fladry is used as a starting example. In Figure 5.19, the blue curve represents the scenario with no financial support and defines the threshold at which producers begin to see positive financial returns. Any point below this curve indicates a situation in which the producer realizes a net positive financial outcome at the respective risk and practice efficiency levels. Under 50% practice subsidization, the curve shifts out (left), indicated by the orange curve. Under the orange curve there is greater overall space which indicates many more combinations of practice efficiency and risk level in which a producer realizes positive monetary value from implementing the practice. Next, when a 25% livestock compensation is considered the curve shifts in (right), meaning there are fewer feasible solutions. And when a 25% compensation is offered on top of the 50% practice subsidy, the curve shifts out (left) represented by the red curve. Ultimately this curve sits between the orange and blue curves indicating that there are more positive financial scenarios for a producer than having no supports, but less than when a producer only has the 50% practice subsidy.

Figure 5.20 shows all five practices under both a 50% practice subsidy, 25% livestock compensation and both a subsidy and compensation. As observed, the greatest amount of red i.e. the least amount of net positive financial outcomes, occurs in the middle column, which simulates livestock compensation. The leftmost column which simulates practice subsidy has the greatest amount of green and thus net positive financial outcomes. Lastly, the right column simulating combined practice subsidy and livestock compensation has more positive financial outcomes than just compensation but less than just subsidy. This trend across all practices agrees with the overall trend from Figure 5.19. An important thing to note from figure 5.20 is that although carcass composting may appear to be unaffected by changes in financial support, the practice is still impacted. Despite there being a consistent visual distribution of green across columns, the actual financial values are still shifting to reflect the broader trend.

It is important to emphasize that these financial outcomes are in direct relation to the implementation of predation prevention practice not general financial outcomes. This means that although receiving compensation for livestock loss is a significant financial support, it ultimately decreases the overall PLI a producer may face from wolf predation which in turn lowers overall incentive to employ predation prevention practices, weakening long term mitigation efforts.

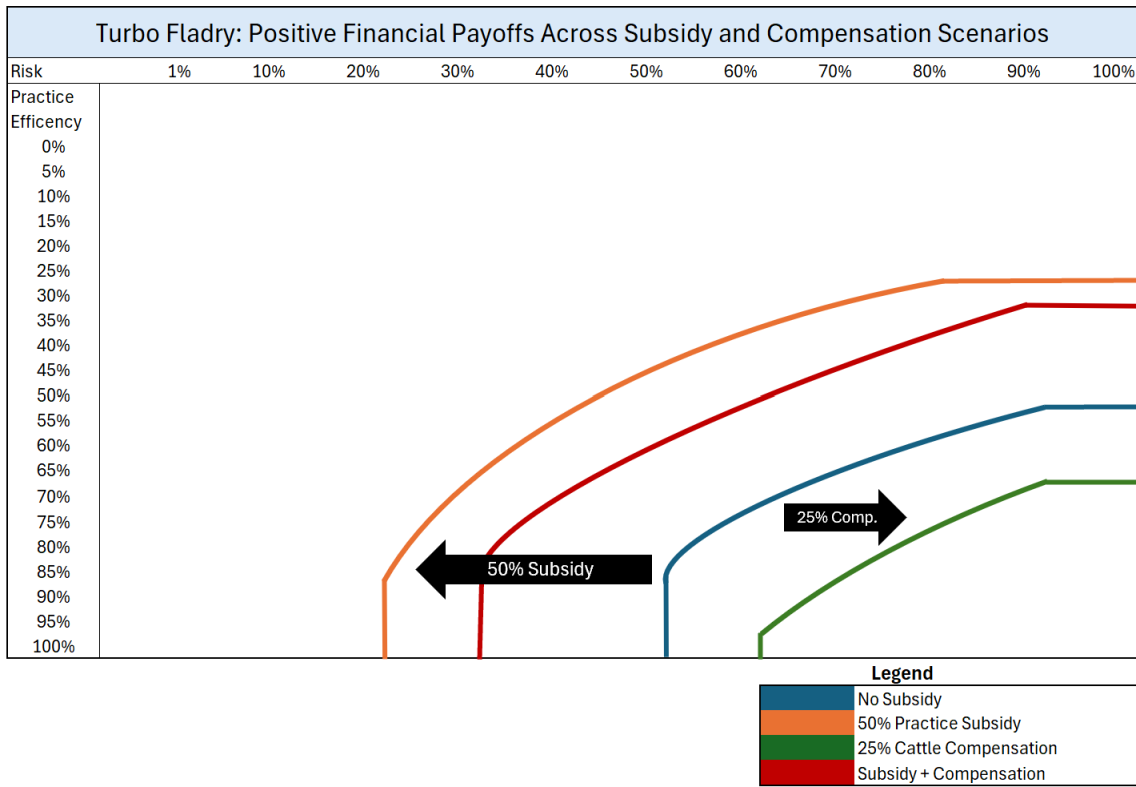


Figure 5.19 – Impact of Practice Subsidy and Loss Compensation on Financial Incentives

6 – Conclusion

This study analyzed the potential financial feasibility of implementing five non-lethal mitigation practices used to deter wolf-livestock predation under varying conditions of predation risk and practice efficiency with consideration for financial support mechanisms. The practices in question were turbo fladry, electrified night penning, range riding, carcass composting and LGDs. My findings are based on the examples I used and should largely be applicable across other situations, but not exclusively. The findings indicate scenarios with relatively high risk of predation are more likely to yield cost-effective outcomes. Likewise, practices that cost less or that are more effective are more likely to be feasible. For many of the scenarios I looked at, the feasibility was moderate, or even weak. It is important to emphasize that producers that have to worry about predation are the exception, not the rule, and therefore may have conditions that are more likely to be feasible, like high risk. In addition, producers may be able to lower the costs of mitigation where the effort is warranted.

Our model predicts the probability of a single conflict. However, multiple animals may be predated. And, as we showed, mitigation will be more feasible when there are more damages. Research shows that indirect losses can be significant, and in the view of many, may exceed direct losses. Therefore, we considered multiple losses, which could include other known predations, indirect losses, or even predations from other predators such as coyotes. Under the scenario of multiple animals predated within a single conflict occurrence or across the span of a year, turbo fladry begins to break even at two predated cattle animals, at a 60% risk and a moderate to high practice efficiency (>50%). The implementation of a LGD is similar to turbo fladry in that realistic break-even efficiencies become achievable at two predated animals with a risk of predation over 70% and even lower required practice efficiency at three or more predated cattle. Carcass composting remains financially positive even at one predated animal if the risk of predation is greater 10%. Range riding and electrified night penning require greater numbers of cattle and sheep

predation as they don't realize possible efficiency (efficiencies less than 100%) until the range of five and four livestock animals respectively. These results show that producers should be careful to consider all losses when evaluating the feasibility of mitigation.

We also considered subsidization of mitigation and compensation for losses. A 50% subsidization rate for predation prevention practices increased the scenarios at which each practice experienced positive financial gains by a moderate margin. Within this study with zero practice subsidy, turbo fladry needs either high efficiency (>85%) and moderate risk of predation (>50%) or moderate efficiency and high risk of predation to start realizing net gains. In the presence of a 50% turbo fladry subsidy, practice efficiency and risk of predation just need to exceed 50% to start realizing gains. The subsidization of a LGD follows the same trend as turbo fladry. Subsidized carcass composting becomes considerably more profitable at each predation and risk scenario saving the producer \$140 on average. Range riding and electrified night penning also see increased outcomes of financial feasibility under 50% subsidization; however, risk of predation and practice efficiency must remain moderate to high (approximately >50% for electrified night penning and >80% for range riding).

This provides greater motivation for the continuation and enactment of more state programs that partially or fully subsidize non-lethal mitigation practices. Currently, under the specifications of this study, without subsidization, producers may not have high incentive to implement predation practices unless they reside in an area with a relatively large risk of predation and indirect losses are considerable. Producers would also have to be able to employ their mitigation practice(s) with moderately high efficacy.

Another important factor to consider is the impact of livestock loss compensation on the incentive to implement predation prevention practices. The results of this study indicate that compensation for livestock loss decreased the quantity of positive financial outcomes from practice implementation across the observed practices. This is to say livestock compensation decreases the financial incentive to implement prevention practices not the actual monetary gain realized by producers. Most state compensation programs do not provide compensation multipliers, meaning they do not compensate for missing livestock presumed to be

from wolf predation. Additionally, a couple of state compensation programs require proof that preventative measures are in place before compensation is approved. Under the assumption that a producer would only be able to receive compensation for a confirmed or probable loss of livestock a fraction of the time, it would always be more financially beneficial to implement a fully subsidized prevention practice than risk relying on compensation payouts.

Overall, for this study's specifications, range riding had the highest cost of implementation, with a total annual cost of \$29,461.60 for one range rider working 30 hours a week managing over 900 cattle. When split across five operations this comes out to \$5,892.32 per operation for range riding with the greatest expense being attributed to the cost of labor making up approximately 88% of the total cost. LGD is the next most costly practice at an annual cost of \$2,464.18, followed by \$2,204.05 for turbo fladry, \$619.93 for electrified night penning and \$280.64 for carcass composting. The highest budget items within this study for turbo fladry, electrified night penning, carcass composting and LGD are flagged polywire, maintenance labor, front end loader use/rental cost, and dog food respectively.

The results indicate the highest likelihood of experiencing financial profitability comes from implementing carcass composting followed by turbo fladry, livestock guardian dog, electrified night penning and then range riding. These results are directly tied to the cost of each practice in relation to the value of the livestock the practice is protecting and tie to the scenarios presented within this study and do not make a statement about overall performance. Ultimately, many other factors could impact a producer's individual success with each practice. For example, specific landscapes, the ability to pre-source practice materials and equipment, previous knowledge of the practice and employment ability, presence of predators beyond wolves, etc.

One limitation of this study is that the sensitivity analysis depends, in part, on the accuracy of the MaxEnt species distribution model. Although the model shows a relatively good fit for accuracy, the underlying conflict occurrence data did not in every case differentiate between injury and death, although the majority were reported as death of livestock. Additionally, the model estimates the probability of at

least one wolf-livestock conflict occurring at a specified site but does not account for the likelihood of multiple predations. This uncertainty motivated the sensitivity analysis to consider scenarios of multiple livestock predations within an occurrence.

Another limitation is the preciseness in data on the efficacy of individual or combined non-lethal mitigation practices, especially across operation and deployment style. To address this, the tool is designed to display payout across varying efficiency levels to allow users to compare expected outcomes against required conditions which better equip producers to make the best personal decision for their operation. Ultimately, the scenarios in which financial gain/loss were simulated were for a generalized quantity of each practice and results do not reflect all instances of practice implementation. It is important to consider that predation prevention practices protect against all predators in the area, not just wolves, therefore the financial gain from practice use could be greater than the base financial gains stated in this study.

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Appendix A - Enterprise Budgets

(the following study is under review as an Extension publication at Colorado State University)

The cost of wolf mitigation and prevention practices, 2025.

Mia Morones, Dana Hoag, Dan Mooney, Stewart Breck, Jon Salerno

Colorado State University, Research Assistant, Professor, and Associate Professor in Dept. of Agricultural and Resource Economics, Research Scientist, USDA Wildlife Services, and Associate Professor in Human Dimensions of Natural Resources, respectively.

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Wolves sometimes target livestock as they hunt for food, leading to conflicts with ranchers. Finding ways to protect livestock is therefore essential as society seeks to enhance wolf populations in several U.S. states. Fortunately, by implementing effective deterrents, such as non-lethal predator control methods, proper fencing, and herd management strategies, producers can reduce losses while minimizing use of lethal control. There are several effective non-lethal and proactive strategies to help prevent wolves from killing livestock.

- Physical barriers, such as reinforced fencing and fladry (flags attached to fences that deter wolves), can help keep wolves away from livestock.
- The use of guard animals, especially dogs, but also including llamas and donkeys, can provide excellent protection particularly in large open landscapes.
- Human presence, such as range riders who patrol grazing areas, also discourages wolves from approaching herds.
- Additionally, noise-making devices, lights, and other scare tactics can serve as temporary deterrents.
- Modifying grazing practices by keeping livestock in closer, well-monitored groups
- Removing carcasses that might attract predators can further reduce the risk of wolf attacks.

By using or combining these methods, ranchers can reduce conflicts while promoting or tolerating coexistence with wolves.

Many U.S. states with wolves provide financial and technical help for ranchers that includes non-lethal prevention. There are several good publications with detailed descriptions, such as (Oregon Department of Fish and Wildlife, 2022; Lance, Primm, & Inman, 2023; Stone, S. A., 2016). Examples can be found throughout this publication, especially in the Appendix. Despite several good publications about these practices, there is little published about what they cost. Knowing about potential practice costs could be valuable for those considering adopting them or to those wishing to provide financial assistance for their adoption. Producers can use this information to compare different systems that they want to consider and to evaluate whether they are worth their cost compared to the savings provided through a reduction in livestock losses.

We prepared this document to provide information about current costs to adopt a variety of non-lethal practices, including turbo fladry, electrified night penning, carcass removal, range riding, livestock guardian dogs and deterrents. Of course, costs vary substantially depending on the size of the operation, local laws, labor rates and availability, building materials, and other factors. To help better target estimates, we provide free access to an Excel file where anyone can tailor the information to represent their own unique circumstances ([Excel file](#))^a. Users may also want to consider making adjustments directly from this report without using the Excel file. Advice for making adjustments and references and links to other documents with more information are provided in the Appendix.

a-You can download and use this Excel file on your own computer. It cannot be used directly online: <https://drive.google.com/drive/folders/1m3bzGVyXqWTMhGI--ACncK81Dbr54sgm?usp=sharing>

Enterprise Budgets

In the following pages we provide enterprise budgets with cost estimates for each practice. We support these budgets with detailed information and notes in the Appendix. Since everyone's situations are different, we also offer information to help users make adjustments that customize costs to meet their own unique needs. We found that many circumstances can affect costs, but in most cases, a user will know whether they apply to their situation. For example, some producers may want to account for an increase in the cost of maintaining electric fence or fladry if they need extra labor because of deep snow or difficult terrain.

To account for annualized costs, each budget utilizes a "useful life" to incorporate practices that use materials that can be reused from year to year. The process to annualize these costs is amortization in which a lump sum value is portioned into yearly amounts based on the item's useful life, the interest rate, and the original cost (much like a mortgage to pay interest and principal over a given amount of time). In the case of these budgets, a standard interest rate of 4% is assumed, however, this can be adjusted in the excel file.

TURBO FLADRY

Turbo fladry is a practice that employs a string of nylon flags that are incorporated into electric wire. Wolves are considered neophobic animals, which means they fear things that are unfamiliar. The waving of the bright flags in the wind discourages wolves from approaching the area surrounded by fladry. For turbo fladry to remain effective and wolves to not become habituated to the flagging, experts advise that fladry should not be used for more than a couple of months at a time and only on smaller pieces of property like calving or lambing pastures. The budgets below are for Turbo Fladry. Fladry without electrification (not shown) can save money but is thought to be less effective.

Turbo Fladry Fence Enterprise Budget - Total Costs for 1 Mile(s) of Fencing						2025
Estimated Production Costs						
DIRECT COSTS						
ITEM	UNIT	COST PER UNIT	QUANTITY	PER 1 MILE(S)	USEFUL LIFE (Yrs)	ANNUALIZED COST (\$/mile/yr)
MATERIALS & SUPPLIES						
Flagged Poly Wire + Delivery	mi	\$4,668.00	1	\$4,668.00	5	\$1,048.56
Electric Fence Charger	charger	\$300.00	1	\$300.00	5	\$67.39
Ground Rod Set	set	\$62.00	1	\$62.00	5	\$13.93
Galvanized steel wire	mi	\$26.99	4	\$107.96	5	\$24.25
Fiberglass Posts	1 post	\$1.99	275	\$547.25	5	\$122.93
Fiberglass Post Insulators	1 insul.	\$0.52	275	\$143.00	5	\$32.12
T-posts	1 post	\$14.00	10	\$140.00	5	\$31.45
T-post Insulators	1 insul.	\$0.50	10	\$5.00	5	\$1.12
Electric Gate Handles	1 handle	\$3.29	2	\$6.58	5	\$1.48
Fladry Reel	1 reel	\$100.00	2	\$200.00	5	\$44.93
Total Material Expenses				\$6,179.79		\$1,388.15
EQUIPMENT/VEHICLE OR SIMILAR						
Pick-Up Truck	mi	\$0.67	20	\$13.40	NA	\$13.40
Trailer	mi	\$0.25	10	\$2.50	NA	\$2.50
Snowmobile	mi	\$0.00	10	\$0.00	NA	\$0.00
Total Vehicle Costs				\$15.90		\$15.90
LABOR						
Installation	hours	\$20.00	20	\$400.00	NA	\$400.00
Maintenance and Repair	hours	\$20.00	20	\$400.00	NA	\$400.00
Total Labor Expenses				\$800.00		\$800.00
Total Annualized Costs/Year/1 Mile						\$2,204.05

** For the purposes of this enterprise budget, materials included will only be those that go directly into the electric fencing and that remain in the field, as well as labor costs. General equipment like gloves, voltmeter, post pounder, etc. that are likely to already be in the possession of a rancher or farmer are treated as fixed costs and excluded from the budget.

NIGHT PENNING LIVESTOCK

Another option for securing and protecting livestock is by night fencing/penning using various forms of temporary electro net or poly wire. This practice works by keeping livestock in a secure location surrounded by electrified fencing during the night when predation is most likely to occur. This practice can be used in conjunction with other practices such as fox lights, sound alarms or livestock guardian dogs. Guidelines for night penning are included in the “The Electric Fencing Producer Tool Kit” published by the Western Landowners Alliance (Collins et al., 2024) supported the foundation of this budget sheet.

This document accounts for two different methods of approaching calculated annual costs. The first is the ‘**Perimeter Method**’ which asks directly how many feet of fencing a producer is interested in and calculates costs from there. The second method, the ‘**Quantity of Sheep Method**’, which asks the producer how many sheep they plan to pen and from there calculates how many feet of fencing would be required to fulfill the assumption that each sheep has their own 25 square feet of space. We give equivalent examples below using both methods. This method can also be used for cattle, but we only provide information for sheep.

Perimeter Method

Electrified Night Fencing Enterprise Budget - Total Costs for a 280'						2025
Estimated Production Costs						
DIRECT COSTS						
ITEM	UNIT	COST PER UNIT	QUANTITY	PER 280 FEET	USEFUL LIFE (Yrs)	ANNUALIZED COST (\$/fence/yr)
MATERIALS & SUPPLIES						
Sheep and Goat Netting	rolls	\$179.99	2	\$359.98	3	\$129.72
Fence Charger	charger	\$255.99	1	\$255.99	5	\$57.50
Solar Panel	panel	\$219.99	1	\$219.99	3	\$79.27
Solar Panel Battery	battery	\$139.00	1	\$256.99	3	\$92.61
Total Material Expenses				\$1,092.95		\$359.10
EQUIPMENT/VEHICLE OR SIMILAR						
Pick-Up Truck	mi	\$0.67	5	\$3.35	NA	\$3.35
Total Vehicle Costs				\$3.35		\$3.35
LABOR						
Installation	hours	\$20.00	1	\$20.00	NA	\$20.00
Maintenance and Repair	hours	\$20.00	8	\$160.00	NA	\$160.00
Penning Training	hours	\$20.00	6	\$120.00	NA	\$120.00
Total Labor Expenses				\$180.00		\$300.00
Total Annualized Costs for a 280' Perimeter Fence						\$662.45

**Pen is assumed to be circular in shape.

Quantity of Sheep Method

The first method, shown above, asks producers their desired preference for perimeter length of electrified penning and the budget sheet will autofill based on that input. The second method asks a producer how many sheep they have in their flock and then assumes that each sheep should require 25 square feet of space. This was based on the reports of several individual ranchers and organizations that recommended 16-25 square feet per animal. However, this number can be adjusted based on the preference of the producer in the adjustment questions.

Electrified Night Fencing Enterprise Budget - Total Costs for a 250 Head Flock of						2025
Estimated Production Costs						
DIRECT COSTS						
ITEM	UNIT	COST PER UNIT	QUANTITY	PER Perimeter (ft) MILE(S)	USEFUL LIFE (Yrs)	ANNUALIZED COST (\$/fence/yr)
MATERIALS & SUPPLIES						
Sheep and Goat Netting	rolls	\$179.99	2	\$359.98	3	\$129.72
Fence Charger	charger	\$255.99	1	\$255.99	5	\$57.50
Solar Panel	panel	\$219.99	1	\$219.99	3	\$79.27
Solar Panel Battery	battery	\$139.00	1	\$256.99	3	\$92.61
Total Material Expenses				\$1,092.95		\$359.10
EQUIPMENT/VEHICLE OR SIMILAR						
Pick-Up Truck	mi	\$0.67	5	\$3.35	NA	\$3.35
Total Vehicle Costs				\$3.35		\$3.35
LABOR						
Installation	hours	\$20.00	1	\$20.00	NA	\$20.00
Maintenance and Repair	hours	\$20.00	8	\$160.00	NA	\$160.00
Penning Training	hours	\$20.00	6	\$120.00	NA	\$120.00
Total Labor Expenses				\$180.00		\$300.00
Total Annualized Costs for a 250 Head Flock of Sheep						\$662.45

RANGE RIDING

Range riding is a wolf-livestock conflict reduction practice that employs skilled riders to monitor livestock and predator interactions. Range riding involves increased human presence on rural rangelands by implementing consistent monitoring of predator presence, implements predator hazing when necessary and monitors the health and behavior of the herd to reinforce group resilience. Range riders can be current ranch operation owners or employees, or they can be contracted out from federal and state wildlife programs and other NGOs. The range riding season typically spans 6 months to coincide with the cattle grazing season from the beginning of May to the end of October, however this may alter slightly depending on the region and needs of the location.

Range Riding Enterprise Budget						2025
Total Costs for one Managed Parcel						
Estimated Production Costs						
DIRECT COSTS						
ITEMS	UNIT	COST PER UNIT	QUANTITY	TOTAL	SALVAGE VALUE	ANNUALIZED COST
MATERIALS & SUPPLIES						
Cell phone/gps	month	\$40.00	6	\$240.00	NA	\$240.00
Bear Spray	item	\$40.00	1	\$40.00	NA	\$40.00
Tarps/bags	item	\$19.98	2	\$39.96	3	\$14.40
Total Material Expenses				\$319.96		\$294.40
EQUIPMENT/VEHICLE OR SIMILAR						
Pick-Up Truck	mi	\$0.67	1440	\$964.80	NA	\$964.80
Trailer	mi	\$0.25	960	\$240.00	NA	\$240.00
Horse	day	\$15.00	96	\$1,440.00	NA	\$1,440.00
ATV/UTV	mi	\$0.22	96	NA	NA	NA
Total Vehicle Costs				\$2,644.80		\$2,644.80
LABOR						
Range Rider	hours	\$30.00	576	\$17,280	NA	\$17,280.00
Total Labor Expenses						\$17,280.00
Total Annual Costs (1 rider, 0 ATVs, 1 horse(s), 6 months, 20 hours/wk, and 25000 acres)						\$20,219.20

** Factors used for these calculations can vary significantly. These include forest cover, terrain, range rider skills, carnivore activity, safety precautions, scope of rider duties, etc. Also, additional equipment, such as drones, can add costs.

CARCASS REMOVAL

A practice that involves separating a deceased carcass or bone pile from an active ranching operation and properly decomposing the remains so that they can be reused for fertilizer or further carcass composting. Livestock carcasses as well as aged bone piles can act as an attractant for predators such as wolves. Thus, relocating carcasses to off-site centralized facilities can help in limiting the presence of wolves. The largest variable in these costs is probably size. Costs go down as the size goes up, which has led some producers to create cooperative efforts. A simpler version of this system does not include composting, as carcasses are disposed of in alternate places such as landfills.

Cost Per Head Method

Colorado - Bin System Carcass Composting Enterprise Budget for ~ 100 Head of Livestock						2025
Estimated Production Costs						
DIRECT COSTS						
ITEM	UNIT	COST PER UNIT	QUANTITY	TOTAL	USEFUL LIFE (Yrs)	ANNUALIZED COST (\$/herd/yr)
MATERIALS, SUPPLIES & PERMITS						
Long-Stem Compost Thermometer	1 therm.	\$64.99	1	\$64.99	10	\$8.01
Hay moisture probe	1 probe	\$199.00	1	\$199.00	10	\$24.53
Compost Site Lease Fee	fee	\$150.00	1	\$150.00	NA	\$150.00
Wood Chips (bulking agent) + delivery fee	cubic yard	\$25.00	300	\$6,800.00	NA	\$6,800.00
Sprinklers	sprinkler	\$104.96	3	\$314.88	5	\$70.73
Water well installation	well	\$5,000.00	1	\$5,000.00	5	\$1,123.14
Hose timer	timer	\$69.99	2	\$139.98	5	\$31.44
Electric Fence	0.25 mile	\$1,702.30	1	\$1,702.30	NA	\$1,702.30
10' Jersey barriers + delivery fee	barrier	\$615.00	20	\$12,300.00	10	\$1,516.48
Concrete pad	sq ft	\$9.00	1200	\$10,800.00	10	\$1,331.54
Total Material Expenses						\$12,758.18
EQUIPMENT/VEHICLE OR SIMILAR						
Pick-Up Truck	miles	\$0.67	3000	\$2,010.00	NA	\$2,010.00
Front-end/skid steer loader	day	\$100	100	\$10,000.00	NA	\$10,000.00
Total Machinery Costs						\$12,010.00
LABOR						
Installation	hours	\$30	80	\$2,400	10	\$295.90
Maintenance	hours	\$30	100	\$3,000	NA	\$3,000.00
Carcass Pick-up	hours	\$30	30	\$900	NA	\$900
Total Labor Expenses						\$3,295.90
Total Annualized Costs						\$28,064.08
Total Annualized Costs/Head of Livestock						\$280.64

** Costs include composting components such as bulking material, bin structures, perimeter fencing, carcass collection and other common composting materials.

** Any costs to comply with water contamination or other regulations (e.g. water quality monitoring, drainage collection, site and regulatory fees, etc.) are not included, but could be substantial.

Cost Per Mile Method

Carcass Composting Fence Enterprise Budget - Total Costs for 0.25 Mile(s) of Fencing						2025
Estimated Production Costs						
DIRECT COSTS						
ITEM	UNIT	COST PER UNIT	QUANTITY	PER MILE(S)	USEFUL LIFE (Yrs)	ANNUALIZED COST (\$/mile/yr)
MATERIALS & SUPPLIES						
Woven Wire Fencing	roll	\$452.25	7	\$3,165.75	5	\$711.11
Turbo Braid	roll	\$124.99	7	\$874.93	5	\$196.53
Electric Fence Charger	charger	\$300.00	1	\$300.00	5	\$67.39
Ground Rod Set	set	\$62.00	1	\$62.00	5	\$13.93
Fiberglass Posts	1 post	\$1.99	68.75	\$136.81	5	\$30.73
Fiberglass Post Insulators	1 insul.	\$0.52	68.75	\$35.75	5	\$8.03
T-posts	1 post	\$14.00	10	\$140.00	5	\$31.45
T-post Insulators	1 insul.	\$0.50	10	\$5.00	5	\$1.12
Electric Gate Handles	1 handle	\$3.29	2	\$6.58	5	\$1.48
Geared Reel	1 reel	\$100.00	2	\$200.00	5	\$44.93
Total Material Expenses				\$4,926.82		\$1,106.70
EQUIPMENT/VEHICLE OR SIMILAR						
Pick-Up Truck	mi	\$0.67	20	\$13.40	NA	\$13.40
Trailer	mi	\$0.25	10	\$2.50	NA	\$2.50
Total Vehicle Costs				\$15.90		\$15.90
LABOR						
Installation	hours	\$20.00	40	\$800.00	5	\$179.70
Maintenance and Repair	hours	\$20.00	20	\$400.00	NA	\$400.00
Total Labor Expenses				\$1,200.00		\$579.70
Total Annualized Costs/Year/0.25 Mile						\$1,702.30

LIVESTOCK GUARDIAN ANIMAL

Livestock guardian dogs can be a useful conflict reduction measure for wolf-livestock predation. The practice utilizes large dog breeds that have historically been bred to protect domesticated animals such as livestock. Unlike pet dogs, livestock guardian dogs (LGDs) are bonded and cohabitate with their livestock, acting as a full-fledged member of the flock or herd. These dogs serve as an extra layer of protection to livestock by conducting perimeter patrols, marking territory, barking/alerting and fighting or chasing predators.

Livestock Guardian Dog Enterprise Budget						2025
Estimated Production Costs						
DIRECT COSTS						
ITEMS	UNIT	COST PER UNIT	QUANTITY	TOTAL	USEFUL LIFE (Yrs)	ANNUALIZED COST (\$/dog(s)/yr)
MATERIALS & SUPPLIES						
Guard Dog + transportation fee	animal	\$1,101.00	1	\$1,101.00	6	\$210.03
Neuter/spay	procedure	\$300.00	1	\$300.00	8	\$44.56
Dog food	lb	\$1.67	686	\$1,145.95	NA	\$1,145.95
Annual vaccinations	vaccines	\$403.00	1	\$403.00	NA	\$403.00
Microchip	microchip	\$50	1	\$50.00	8	\$7.43
Shelter	shelter	\$250.00	1	\$250.00	5	\$56.16
Insurance	fee	\$100.00	1	\$100.00	NA	\$100.00
Miscellaneous items	NA	\$200.00	1	\$200.00	NA	\$200.00
Total Material Expenses				\$3,549.95		\$2,167.12
LABOR						
Training	hours	\$20.00	100	\$2,000.00	8	\$297.06
Total Labor Expenses						\$297.06
Total Annual Cost for 1 Guardian Dog(s)						\$2,464.18

DETERRENT DEVICES

Fox Lights - A predator deterrent that is meant to mock the light that would come from someone walking around patrolling with a flashlight. Depending on the brand purchased, the fox lights will flash blue, white and red light periodically in specific sequences. A sensor automatically turns the light on at night and off at dawn and can be seen from approximately 2 kilometers away.

Solar Sound Alarms - A predator deterrent device that typically has a sensor to detect the motion of unwanted animals that reach a range of 16-26 feet of a specific location. When triggered, the alarm will emit a 130 dB sound alarm and strobe light. These alarms can be either solar or USB charged.

Game Cameras - Unlike a traditional deterrent device, a game camera will not deter predators in the moment, but reviewed footage can give insight into predator movement and frequency allowing better opportunity to more effectively employ other deterrents and practices.

Device:	Links:	Price by Source:	Annualized Price Range
Fox Light	1. Amazon.com 2. Electric Fence Online	1. \$97.74 2. \$122.82	\$21.96 - \$27.59
Solar Sound Alarm	1. WorldTechOutlet.com 2. Aroflit 3. Amazon.com	1. \$49.99 2. \$39.95 3. \$15.99	\$3.59 - \$11.23
Game Camera	1. Amazon.com 2. Tractor Supply Co 3. Walmart.com	1. \$59.95 2. \$129.99 3. \$82.11	\$13.47 - \$29.20

Disclaimer and other considerations:

**None of these devices are being promoted as a paid partnership of any kind. The links are meant to serve as examples of predator deterrent devices. The products displayed by these links cannot guarantee the effectiveness of each device nor how they compare to one another.

**The annualized cost range of each device is calculated assuming a five-year life span of each of these devices with a 4% interest rate.

**There likely exist products that lay in a price range outside of these estimated ranges depending on sales, year sold, changes in manufacturing, etc.

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Appendix

Notes and Details to Support Enterprise Budgets

Note: A key to internet link addresses is at the end of this Appendix

TURBO FLADRY

Adjustment questions in Excel

1. How many miles of fencing do you need?	1
2. Do you live in an area that is particularly rocky or has rugged terrain or deep snow?	No
3. Will you require a snow machine for installation?	No

Total fencing cost is determined by length in miles. Areas with rough terrain raise the cost by being more difficult to fence, and areas with deep snow require moving the fence up and down. You can address all of these by simply adding a fraction onto the total cost or on any item cost.

Supplemental Readings

1. [NRDC: INSTALLING TURBO FLADRY - AN INFORMATIONAL GUIDE](#) (Natural Resources Defense Council, 2020)
2. [People and Carnivores – Electrified Fladry](#) (Primm et al., 2018)
3. [Washington Department of Fish and Wildlife](#) (WDFW, 2015)

Assumptions and data:

- * The (Natural Resources Defense Council, 2020) has a detailed producer guide that provides a list of required materials for turbo fladry and additionally provides the basics of the material list for this budget sheet. Some of the quantities of materials from the NRDC were given as a range, so in that case the median number was listed as the quantity within this budget sheet.
- * Based upon published informational guides and suggestions from people who regularly install turbo fladry, fencing is typically only effective for a two-to-three-month period, which is averaged over 75 days here to calculate labor costs (Natural Resources Defense Council, 2020).
- * Factors used for these calculations can vary significantly. These include snow, wind, terrain, and labor.

Junco Industries is one of the only large-scale manufacturers of turbo fladry in the United States. Based on communication with the chief business development officer, the 2024 prices can be viewed in the tables below. Three different fladry products are available for purchase with each

product using PBSC4 wire and using 18-inch-long flags, spaced 18 inches apart from each other. For the most basic fladry, a quarter mile is priced at \$1,167 which includes delivery costs.

Pricing for 5 Miles or Less:

Material	Price/0.25 mi	Wire	Flag length	Space between flags	Price/mile
Deluxe Fladry, 420D Red Nylon	\$1,167.00	PBSC4	18"	18"	\$4,668.00
Polyester UV Coated 600D fabric	\$1,206.00	PBSC4	18"	18"	\$4,824.00
18oz Vinyl coated Polyester Scrim	\$1,243.00	PBSC4	18"	18"	\$4,972.00

*Prices include cost of delivery/transportation

Pricing for 6+ Miles:

Material	Price/0.25 mi	Wire	Flag length	Space between flags	Price/mile
Deluxe Fladry, 420D Red Nylon	\$1,137.00	PBSC4	18"	18"	\$4,548.00
Polyester UV Coated 600D fabric	\$1,155.00	PBSC4	18"	18"	\$4,620.00
18oz Vinyl coated Polyester Scrim	\$1,212.00	PBSC4	18"	18"	\$4,848.00

*Prices include cost of delivery/transportation

Most prevalent retailers: Tractor Supply Co., Premier 1 Supplies, ULINE and Amazon

- (1) Electric Fence Charger: [Electric Fence Energizers - Premier1Supplies](#) **\$300**
- (2) Ground Rod Set: [field-guardian-complete-grounding-kit-6-ft-900125](#) at [Tractor Supply Co.](#)
- (3) Grounding Kit: [6 ft. Complete Grounding Kit](#) **\$62**
- (4) Galvanized Steel Wire: [Red Brand 1,320 ft. x 170 lb. Galvanized Electric Fence Wire, 17 Gauge at Tractor Supply Co](#) (\$26.99 x 4) = **\$107.96**
- (5) Fiberglass Posts: [CountyLine 3/8 in. x 4 ft. Fiberglass Rod Post](#) at [Tractor Supply Co](#) (\$1.99 x 275) = **\$547.25**
- (6) Fiberglass Post Insulators: [Patriot Rod Post Insulators, Yellow, 25-Pack](#) at [Tractor Supply Co](#) (\$0.52 x 275) = **\$143**
- (7) T-Posts: [ULINE Search Results: Safety Fence T Post](#) (\$14 x 10) = **\$140**
- (8) T-Post Insulators: [American Farm Works Screw-On T-Post Insulators for 1.25 and 1.33 in. Studded T-Posts, Yellow, 25-Pack](#) at [Tractor Supply Co](#) (\$0.50 x 10) = **\$5**
- (9) Electric Gate Handles: [Rubber Gate Handle at Tractor Supply Co](#) (\$3.29 x 2) = **\$6.58**
- (10) Fladry Reel: [Amazon.com: EFencSolv Electric Fence Mega Geared Reel PK1 : Patio, Lawn & Garden](#) (\$100 x 2) = **\$200**

For installation of fladry, many producers might have different approaches. A standard fladry reel should be able to hold about 3,000 feet of polywire. Therefore, two reels would be required per

mile, or a producer could choose to refill the reel and only use one. Additionally, some producers might incur additional costs if they choose to use a method to more efficiently spool out the polywire like using a strap backpack mechanism or implementing a system onto an ATV or UTV. Some states, like Colorado and Montana, make a special installation cart available by request.

Gas Mileage

The gas mileage pricing in the budget sheet is based on the 2024 IRS standard mileage rate for operating an automobile for business, charitable, medical or moving purposes such as for use on a ranch. This amount comes out to be \$0.67/mi. As to account for trailer wear and tear, 0.25/mile was assigned based on similar pricing for trailer use for range riding for the Rocky Mountain Landowner Collaborative cost scenarios.

- [IRS issues standard mileage rates for 2024](#) \$0.67/mi

There is a question included in the Excel file that asks the user if they need a snowmobile for installation in the case that they live somewhere that may still have a deep layer of snow on the ground, requiring a snowmobile for installation. If the user responds “No” the budget will not include the cost of using a snowmobile.

Similar to ATV/UTVs, snowmobiles typically get a range from 10-20 mi/gallon. The price of gas on 9/2/24 according to the EIA was \$3.29/gal. For the sake of a conservative guess, 15mi/gal was chosen for the calculations. That would result in a price of approximately \$0.22/mile

Labor

Based on conversations with individuals experienced with electric fence installation, individuals reported that it could take about 4 people five hours to install a mile of turbo fladry fencing. That would equate to approximately 20 hours of installation labor annually however terrain and weather conditions could impact this significantly.

Reports from multiple people indicated that electric fencing typically requires 2 hours of maintenance per week. Under the assumption that the turbo fladry would be employed for approximately 2.5 months (10 weeks) that equates to approximately 20 hours of maintenance labor annually. Labor was priced at \$20/hour although this can vary by employer and state. \$20 is meant to serve as a place holder and the Excel user would have the ability to alter the price to more accurately reflect their scenario.

Additional factors such as ruggedness of terrain, type of soil, and the presence of snow can ultimately impact the feasibility of installation. To account for some of these external factors that impact installation, one of the questions asked to users will be “Do you live in an area that is particularly rocky or has rugged terrain or deep snow?”. The user can choose to say “Yes” or “No”. If the answer is yes, there will be a 1.2 multiplier (a default multiplier when more information is unavailable) added to the installation and maintenance time requirements.

Disclaimer and other considerations:

The biggest factor impacting the feasibility of electric fence installation is snow as well as land terrain and ruggedness. Installation usually coincides with the beginning of grazing season in the late spring. Depending on operation location snow presence can be a real consideration as it may require the use of a snow machine as well as increased installation time requirements as the ground will potentially be hardened, and snow presence would require digging for post installation.

Another consideration is the system in which you choose to spool and unspool the turbo fladry. This budget sheet includes an electric fence geared reel, but other producers may choose to implement a more involved system that integrates the reel into a shoulder strap system or use an automated fladry spooling system connected to an ATV. These systems have the potential to decrease installation time but increase upfront costs.

Wind is another factor that must be considered for maintenance requirements. Intense wind can cause the fladry flags to wrap around the fencing which diminishes the visual impact of the flagging and requires increased maintenance time.

NIGHT PENNING LIVESTOCK

Adjustment Questions in Excel – Perimeter method

Perimeter Method		
1. How many feet of fencing do you need?	280	→
2. How many months will you require night penning?	2	
		Perimeter (ft)
		280

Adjustment Questions in Excel – Quantity of sheep method

Quantity of Sheep Method					
1. How many sheep do you have?	250	→	Output	Sq feet needed	Perimeter (ft)
2. How many sq feet per sheep do you wish to have?	25			6250	280
3. How many months will you require night penning?	2				

Supplemental Readings

1. [Western Landowners Electric Fencing Tool Kit](#) (Collins et al., 2024)
2. [Defenders of Wildlife - Livestock and Wolves](#) (Stone, S.A., 2016)
3. [Washington Department of Fish and Wildlife](#) (WDFW, 2015)

Sheep Spacing Guides

- (11) [Understanding How Much Room Does A Sheep Need - Essential Guide](#)
- (12) [Creating A Good Home For Sheep - The Open Sanctuary Project](#)
- (13) [How Much Space Do You Need To Raise Sheep? – Family Farm Livestock](#)

Assumptions and data:

Sheep and Goat Netting

- (14) [Starkline 48 in. x 164 ft. Positive/Negative Electric Sheep and Goat Netting at Tractor Supply Co \(\\$179.99/roll\)](#) – Each roll is 48” tall and 164’ long. The mesh is composed of 10 horizontal strands with vertical strands placed every 7 inches. The netting incorporates 14 preinstalled PVC posts with 6 galvanized double-spiked stakes, so no additional support material is needed.

Fence Charger

- (15) [Energizer: Speedrite 3000 Dual Purpose Energizer, 3 joule — Jeffers \\$255.99](#)
- (16) [Solar Panel: Ghost Controls 30W Monocrystalline Solar Panel Kit with Brackets, No Post at Tractor Supply Co \\$219.99](#)
- (17) [Solar Panel Battery Price: Ghost Controls Battery Box Kit with 2 Batteries and Harness at Tractor Supply Co \\$139.99](#)

Labor

Collins et al., (2024) state that it takes roughly 15 minutes to set up and take down night penning fence, with occasional repairs, the fence will last up to three years and that only light maintenance and repairs are needed throughout the grazing season. To err on the conservative side, one hour of labor was allocated for installation/removal and 30 mins a week was allocated

for maintenance hours. If your operation has particularly difficult terrain, consider increasing this labor requirement to better reflect your needs.

Additionally, sheep won't instinctively know to go to the temporary penning during the night so they must be trained via consistent herding into the enclosure until they instinctively know to head there themselves. One way that has been suggested to allow animals to become adjusted is to use the fencing during feeding times (Stone, 2016). It is also suggested to move the fencing around every so often to not overly disturb the forage. Therefore 6 hours of training was allocated to train the sheep to use the pen.

Disclaimer and other considerations:

For night penning to work properly, sheep or goats do have to be trained to use the fencing. Failure to do so will cause more wear and tear on the penning, which ultimately decreases the lifespan of the fencing. Additionally, because night penning is designed to be a more temporary system with more frequent set-up and take down, weather considerations can impact the installation times. Wet season particularly will increase time demands for set-up.

RANGE RIDING

Adjustment Questions in Excel

	Cattle	Acres
	101-400	25,000
Hours needed/wk	30	10
Average:	20	

Interest Rate	0.04
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Questions:

1. How many months of range riding?	6
2. How large is your herd?	101-400
3. How many acres is your rangeland?	25,000
4. How many miles away is your operation from where you keep horses/ATV/UTV?	15
5. Are you using a horse or ATV/UTV?	Horse
6. Quantity of horses needed?	1
7. Quantity of ATV/UTVs needed?	0
8. Do you live in an area with particularly rugged or rough terrain?	Yes

Tiered Cattle Structure	0 - 100
	101 - 400
	401 - 900
	901 +

Auto suggested:	9. How many hours of riding needed/week?	20
Auto suggested:	10. How many range riders do you require?	1

There are several questions that could affect this budget, including the size, expressed in acres or cattle, length of season, distance, etc. Make adjustments in the cost to arrive at riding location, hours of riding per week, etc. The image from the Excel file shown above includes boxes to the right and left that are used to create the question box.

Supplemental Readings

1. [Western Landowners - Range Riding Tool Kit](#) (Collins et al., 2024)
2. [Conservation Northwest - Range Rider Pilot Project](#) (Conservation Northwest, 2021)
3. [Colorado State University - Wolf Resources Guide](#) (Lance et al., 2018)

Assumptions and data:

The largest expenses for range riding come from employment of labor and transportation costs (horses/ATV/UTV) rather than from materials or supplies.

Truck and Trailer

- (18) Based on the same IRS guidelines from before, truck mileage was priced at \$0.67/mile and trailer mileage (wear and tear) was priced at \$0.25. A major contribution to the costs for a practice like this is the size and scope of the operation which ultimately indicates the amount of transportation and labor that is needed.

For example, based on how the user responds to a set of questions will impact how the budget sheet autofills. In this scenario, there is one range rider, using one horse and no ATVs covering 25,000 acres working 20 hours/week for 6 months.

Range Riding

The number of head and number of acres were the two inputs for which the labor hours suggested were calculated.

Tiered cattle structure suggested for labor requirements:

- 0-100 head would equate to a one-person operation, or ½ FTE at a cost of \$25,000 (20 hours)
- 101 - 400 → 1.5-person operation → ¾ FTE at a cost of \$40,000 (30 hours)
- 401 - 900 → two-person operation → 1 FTE at a cost of \$50,000 (40 hours)

Range riding often occurs over the grazing season which is typically 6 months long. Cost scenarios from the NRCS indicated they used a total of 480 hours of range riding labor over the course of a season which breaks down to 20 hours of labor/week for 50,000 acres. In a different scenario they used a total of 960 hours which breaks down to 40 hours/week for 150,000 acres. Using simple math, this further breaks down to approximately 0.0004 and 0.0003 hours/acre respectively.

Using a combination of these two labor requirement methods, the following formula with the scenario used in the budget sheet which was 300 head of cattle on 25,000 acres of land:

$$\frac{300 \text{ head (30 hours)} + 0.0004*(25,000)}{2} \rightarrow \frac{30 + 10}{2} \rightarrow 20 \text{ hours/week}$$

There is an additional question that asks the user “Do you live in an area with particularly rugged or rough terrain?” The user can choose to say “Yes” or “No”. If the answer is yes, there will be a 1.2 multiplier added to the labor time requirements.

Other

- (19) [Range Rider Pilot Project | Conservation Northwest](#) *A skilled range rider can cost up to \$20,000 or more in a grazing season

ATV/UTV Gas Mileage

ATVs and UTVs typically get a range from 10-20 mi/gallon. The price of gas on 9/2/24 according to the EIA was \$3.29/gal. For the sake of a conservative guess, 15mi/gal was chosen for the calculations. That would result in a price of approximately \$0.22/mile

Daily Horse

\$15/day -- Average daily cost to use a horse for the grazing season. This is meant to include depreciation, feed, and vet care while riding remote ranges and forest allotments to manage and monitor livestock. This cost is taken from the daily cost listed for the BHWC's Upper Big Hole Range Rider program.

Material and Supply Costs

- (20) Bear Spray: [Frontiersman Bear Spray \(9.2 oz\) | Deter Wildlife Attacks - Default Title - My Patriot Supply](#) \$40
- (21) Tarps: [Everbilt 8 ft. x 10 ft. Brown and Silver Heavy Duty Tarp PY008 - The Home Depot](#) (\$19.98/item)

CARCASS REMOVAL

Adjustment Questions in Excel

1. On average, how many carcasses would be composting at this facility?	100
2. What percentage of these carcasses would need to be picked up?	0.75
3. What is the average round trip distance in miles for a carcass pickup?	40
4. What is the average weight of a carcass?	300
5. Required milage of electric fencing?	0.25

Most of the excel questions are related to size, such as the number of carcasses, how many have to be picked up from remote locations, and the distance for pickups. Some producers have created central storage where members can drop off carcasses for later pickup.

Supplemental Readings

1. [Oklahoma State Extension - Mortality Composting](#) (Payne & Pugh, 2017)
2. [SARE - Livestock Mortality Composting](#) (Bass et al., 2005)
3. [Florida SART - Composting Animal Mortalities: A Producer's Guide](#) (Saskatchewan Agriculture, Food and Rural Revitalization, 2005)

Assumptions and data:

Ultimately there are several assumptions that must accompany carcass composting as a mitigation practice due to the variation in which the practice may be conducted. The two most common ways to compost livestock are bin and windrow composting. Bin composting is a when a compost pile is contained by some sort of 3-sided square structure. These three-sided structures can consist of many different materials such as hay bales, jersey barriers, make-shift wooden structures, wood pallets, etc.

Windrow composting is a compost pile that is uncontained and shaped so that it forms an upside-down "V" so that water and other weather elements naturally run off the piles. There are two stages of carcass composting and windrow composting will often be used in conjunction with bin composting as the second stage of the decomposition process (Saskatchewan Agriculture, Food and Rural Revitalization, 2005).

Jersey Barrier

Other non-profit organizations have implemented community style carcass composting sites where ranchers either drop off their deceased livestock or someone comes and collects the carcasses. A common theme among many of these groups was that they implemented jersey barriers to act as the walls of their bins. (Big Hole Watershed Committee, n.d.) and (Montana Department of Transportation, 2007).

The company 48 Barriers charges \$12,300 for 20 used jersey barriers which includes the cost of delivery. Therefore, the per unit cost for a jersey barrier is **\$615/barrier**. This cost, however, is subject to change as location changes, but acts as a reasonable expectation of price. The price does not include offloading; thus, the recipient/customer is expected to be in possession of their

own equipment to do so and be able to offload within one hour of delivery to not incur additional fees. There is also the possibility the jersey barriers can be donated via state DOTs. Other possibilities for bin walls include self-made structures or large haybales.

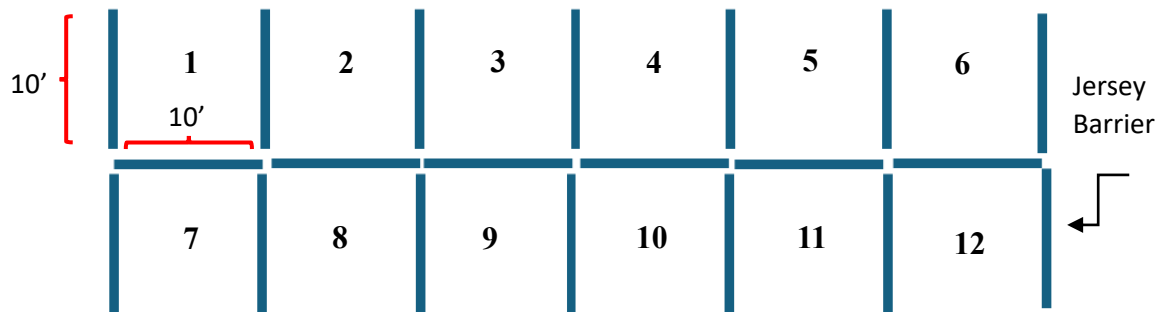
Jersey barrier specifications:

Condition - used

Dimensions - 10'L x 24"W x 32"H

Weight - 3,900 lbs./barrier

Potential Set-up:



The most efficient way to set up 20 barriers is in the configuration above which provides 12 10'x10' bins. Generally, a mature cattle carcass will need approximately 9 by 10 feet of room. A couple calves/yearling or a few sheep carcasses could fit in the same amount of space (Bass et al., 2005). The primary stage of composting, which usually takes around 3-6 months depending on the size of the carcass would occur in the bins

The second stage of composting, which usually takes another 3-6 months depending on the size of the carcass, would occur in open windrow piles within the sites' secured fencing. However, practiced composting facilities can often sufficiently compost multiple carcasses within a pile in much less time. Composting also takes less time the smaller the livestock animals is in size and weight.

Concrete Slabs

- (22) Concrete Slab: [How Much Does a Concrete Slab Cost? \(2025 Prices\)](#) \$6-\$12/sq foot
Having a concrete slab or clay substrate foundation at the base of a compost pile is recommended by many producer guides to livestock carcass composting as this can provide a barrier between the leachate from the compost pile and the ground that could result in biohazardous soil conditions. Concrete slabs can range from \$6-\$12/sq foot. This budget sheet assumes a middle range of \$9/sq foot and requirement of 1200 sq feet (10' x 10' x 12') as referenced by the visual representation above.
- (23) Long-stem Compost Thermometer: [Agtec Heavy Duty Fast Response Compost Thermometer 36in \(0-200°F\)](#) \$64.99
- (24) Hay Moisture Probe: [Agratronix Portable Hay Moisture Tester with Calibration Clip HT-PRO](#) \$199

- Compost Site Lease Fee \$150 – This is based on the Montana Department of Transportation fee for the Big Hole Watershed Committee composting project. *Other states are likely to have different lease fees depending on state regulations.
- (25) Sprinkler and hose: Gorilla ToughLite 5/8 in. x 100 ft. Heavy Duty Garden Hose HYB55800 - The Home Depot \$104.96 x 3 = **\$314.88**
- (26) Hose timer: Rain Bird Professional Grade Hose End Timer at Tractor Supply Co \$69.99 x 2 = **\$139.98**

Well Installation

- (27) 2025 Well Drilling Costs | Average Water Well Installation Cost **\$5000**

There can be potentially large differences in terms of water access and general health and water quality standards related to composting from state to state and even locationally within a given state. A composting facility may need to drill a well to either test the quality of the ground water within the site or if there is limited access to water for the purpose of wetting the compost piles, a facility may need to consider drilling a well to access groundwater for use beyond simply testing. Well installation pricing can vary considerably depending on the depth and width of the well along with the surrounding soil conditions. Typically, they range anywhere from \$3,700 to \$15,300 or \$25-\$65 per cubic foot. This enterprise budget will assume a lower cost well installation as water needs would likely be relatively low due to the seasonality of the operation.

Electric Fence Components and Pricing

A small-scale carcass composting facility or really any composting operation needs fencing capable of preventing predators/scavengers from coming inside. The Montana Blackfoot Challenge recommends using woven wire that has been integrated with top, hot wire. A site capable of composting 100 head of cattle, it was assumed only about a quarter mile of fencing would be needed. There is an annualized enterprise budget for an individualized quarter mile woven wire fencing system above that acts as a direct input into the carcass composting enterprise budget sheet.

- (28) Woven wire: KIWI S-Knot Woven Wire, 16/60"/2", 12 1/2ga, 200' Roll \$452.25 x 7 = **\$3,165.75**
Kencove, a manufacturer of farm fence supplies, produces a variety of woven wire fence rolls. The link above is for roll of 5' fencing with 2x4" spacing and is 200' in length. In order for the fencing to cover a ¼ mile distance, seven rolls would be needed. Woven wire fences are meant for more permanent fencing solutions.
- (29) Turbo Braid: Gallagher Turbo Braid 1312 ft. Plus 328 ft. Extra 7/64in Diameter Highly Conductive Braided Poly Wire with SS and Copper Strands at Tractor Supply Co \$124.99 x 7 = **\$874.93**
Turbo braid was chosen as the hot wire as it is more durable than standard poly wire as it is thicker, braided instead of twisted, has more conductivity and holds up better in the wind. The length of this specific roll of turbo braid is 1,312ft. Assuming that a four or five strand system would be integrated, roughly a 6 roll of turbo braid would be required.
- (1) Electric Fence Charger: Electric Fence Energizers - Premier1Supplies **\$300**
- Ground Rod Set: field-guardian-complete-grounding-kit-6-ft-900125 at Tractor Supply Co.

- (2) [6 ft. Complete Grounding Kit](#) **\$62**
- (10) Geared Reel: [Gallagher Reel ~ Standard 1320 — Powerflex](#) \$100 x 2 = **\$200**
- (5) Fiberglass posts: [CountyLine 3/8 in. x 4 ft. Fiberglass Rod Post at Tractor Supply Co.](#) \$1.99 x 69 = **\$137.31**
- (6) Fiberglass post insulators: [Patriot Rod Post Insulators, Yellow, 25-Pack at Tractor Supply Co.](#) \$0.52 x 69 = **\$35.88**
- (9) [Electric Gate Handles: Rubber Gate Handle at Tractor Supply Co](#) (\$3.29 x 2) = **\$6.58**

Bulking Agent Price

Livestock carcasses are higher in nitrogen so to properly compost, a generous amount of a bulking agent that is high in carbon is required so that the (C:N) ratio is at a sufficient range – typically between 25:1 and 40:1 (Saskatchewan Agriculture, Food and Rural Revitalization, 2005). The most used bulking agent materials are sawdust, woodchips, hay, straw, topsoil, crop residue, etc.

For the purposes of this budget sheet, we’re assuming that the average weight of livestock is 300 lbs., as this is taking into consideration that typically the majority of livestock loss consists of young calves with less frequent losses of cattle and sheep such as cows, heifers, bulls, steers, yearlings, rams, ewes, and lambs.

A typical rule of thumb is that 1 cubic yard is required per 100lbs of carcass (Payne & Pugh, 2017). Therefore, with the assumption that there are 100 head of livestock (cattle and sheep) at an average weight of 300lbs/head, then 300 cubic yards of the bulking agent would be needed:

$$\frac{100\text{head} * 300\text{lbs}}{100\text{lbs}} = 300 \text{ cubic yards}$$

(These numbers can be adjusted according to the specific composting site)

As previously mentioned, multiple materials are suitable for use as the bulking agent. This budget sheet uses woodchip pricing as the input, but depending on where a composting site is regionally, it might be easier or more cost effective to source other materials high in carbon. Expenses can also be cut by using donated chopped crop residue from other agriculturalists.

Woodchips \$25/cubic yard

Pricing for bulking materials can depend on the type of material, the delivery location/distance, and whether excess material like woodchips or hay can be sourced from nearby agricultural operations. Typically, the cost for a cubic yard of a bulking agent can range from \$15-\$30.

- (30) [Bulk Sawdust Pickup & Delivery Prices | Hull Forest Products](#) (For bulk >85 cubic yards it is \$14.50/yard + delivery)
- (31) [Wood Chips for Biomass Fuel & Reactive Playground Surfacing | Hull](#) (\$20/yard FOB mill)
- (32) [Retail Sawdust and Mulch Sales - River City Hardwoods](#) (\$30/yard for mulch) - (\$20/yard of sawdust)

A \$800 delivery fee was added to the yearly bulking agent costs based off NRCS pricing info. Furthermore, about roughly 30% of the mature compost from previous piles can be recycled back into new piles (Saskatchewan Agriculture, Food and Rural Revitalization, 2005). So, to account for this on-site material recycling, 0.8 was multiplied by the final required amount to show that a conservative 20% of the material could come from within-system.

Equipment price

A small-scale composting facility must have semi-regular access to a large piece of equipment that has the ability to lift heavy bulking agents as well as livestock carcasses at varying stages of compost. Previous informational guides have indicated that equipment such as front-end or skid-steer loaders are suitable for this work. Cost scenario data from the NRCS explained that they rented a tractor 100 days out of the year and the farmer they rented it from estimated the cost to be \$100/day. ($\100×100) = **\$10,000**

Labor costs

As of right now, the budget sheet lists hours required for installation at 80 and yearly maintenance/labor at 100 hours which would break down to just over 4 hours a week for 6 months to include activities such as carcass pick-up, pile turning and creation, pile temp checking, hosing, and other maintenance requirements. These numbers are currently only estimates.

Most carcass composting facilities have the option to either have producers drop off their carcasses or have someone come pick them up. For an operation with approximately 100 carcasses, the budget sheet assumes 75% of the carcasses are picked up by the facility and that the average roundtrip mileage for each pickup is 40 miles. These numbers are only placeholders and can be adjusted by the user to account for their site specifications.

Disclaimer and other considerations:

This budget sheet is meant to represent an expected average for annual costs associated with a carcass composting facility. Ultimately every facility is unique and will face individual costs and state specific requirements related to water quality testing, permit fees and construction requirements that impact final costs. Materials listed within the carcass composting budget sheet such as bulking agents (wood chips, hay, crop residue, etc.) from producers, jersey barriers from the state department of transportation and other raw material have been donated in the past to similar organizations that have undertaken large-scale carcass composting. In order to keep expectations for prices more realistic, it is assumed within this budget sheet that no materials are in kind or gifted, but there are likely opportunities to receive some reduced cost or no-cost material inputs.

Weather: Depending on the region, it may be good to consider a bin system with some sort of overhead shelter which can protect from excessive wind and rain. Compost piles cannot become over saturated with water otherwise they run the risk of not composting correctly.

Netting and fencing: Predator and scavenger access can be a real concern meaning proper electric fencing is crucial to success. This budget sheet calculates costs for mesh netting with hot wire, but fencing costs can vary. Another consideration which this budget sheet does not include is overhead netting. Not all facilities have this, but that might be a consideration depending on flying scavengers like birds and disease spread concerns.

Water: A composting facility's access to water is a major factor when considering price variability. To access water, some facilities may need to drill a well. It is also important to abide by state water quality regulations which may call for different water quality testing standards as well as requirements for substrate or concrete pile bases and drainage systems. There may also be specific limitations for what purposes mature compost can be used for within your state.

LIVESTOCK GUARDIAN ANIMAL

Adjustment Questions in Excel

1. How many guardian dogs are you interested in?	1
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Supplemental Readings

1. [University of California Cooperative Extension](#) ((University of California Cooperative Extension, 2019)
2. [Texas A&M AgriLife Extension LGDs](#) (Redden et al., 2015)
3. [Texas A&M AgriLife Extension LGD Diets](#) (Costanzo, 2020)

Assumptions and data:

Guard Dog Pricing and Delivery Fee

Ultimately, the cost of acquiring a guard dog will vary depending on the breed, breeder and the distance the dog must be transported. The price of the livestock guardian dog as well as the delivery fee for this budget sheet is based on the purchase of Turkish Kangal guardians for the USDA APHIS Wildlife Services' Nonlethal Initiative for Livestock Protection Program.

- (33) [Wildlife Services Nonlethal Initiative Fiscal Year 2021 Annual Report.pdf](#)

The FY 2021 Annual Accomplishments report, linked above, states that they were able to purchase 11 Kangal puppies for a slightly discounted amount of \$7,200. This would divide out to be approximately \$655/puppy. The report's cost breakdown also states that vehicle costs added up to \$4,908.41. Although the report doesn't explicitly state what these costs are attributable to, it can be assumed that they were likely the cost of gasoline to drive the puppies across the state and to their respective homes. That would mean transportation costs break down to approximately \$446/puppy for procurement and delivery fee of **\$1,101/puppy**.

Some other sources that support this price range for livestock guardian puppies are:

(Redden et al., 2015) estimated the cost of LGDs to be \$1,000 the first year and \$500 the subsequent years. This would suggest that purchase price for this publication to be approximately \$500 in 2015 dollars.

- (34) [Livestock Guardian Dogs | Willow City Farm](#) – This LGD breeder requests a \$100 deposit and \$500 additional payment at time of pick up, for a total cost of \$600 for a Great Pyrenees puppy which is quite similar to the \$655 price tag for the Kangal puppies (pre deliver/transportation cost).
- (35) [Livestock Guardian Dog Breeder: Breeds Instinctive, Working LGDs](#) (\$500 - \$5000)

Neuter/Spay Costs:

- (36) [How Much Does It Cost to Spay or Neuter a Dog? 2024 Price Guide – Dogster](#) (\$150 - \$700)
- (37) [How Much Does It Cost to Neuter or Spay a Dog? - Spend On Pet](#) (\$150 - \$700)

Annual Vaccination Fees

It is assumed that a rancher would likely provide their livestock guardian dog (LGD) with annual vaccinations that are common of other domesticated dogs. The annual vaccination cost listed in the budget sheet above clumps together heartworm prevention, flea and tick prevention, distemper vaccination, deworming and rabies shots.

Annual Vaccinations (Averages)	
Heartworm prevention	\$78
Flea and tick prevention	\$120
Distemper vaccination	\$50
Deworming	\$140
Rabies shot	\$15 (\$30 required every ~2 years)
Total	\$403

Most veterinary hospitals do not advertise the cost of their vaccinations and preventative services on their websites, so animal care blogs were used to price check current animal care service fees. Many websites listed rabies shots ranging from \$15-\$45 and needing to be administered every 1-3 years which averages to approximately \$15/year and was added on to the other annual preventative care from the table above.

- (38) [How Much Do Dog & Puppy Vaccinations Cost? \(2024 Price Guide\) – Dogster](#)
- (39) [Dog Vaccinations Cost: What You'll Pay](#)
- (40) [Rabies Vaccine for Dogs: How Often Do Dogs Need Shots? – Care Credit](#)

Microchip Cost

Not all LGDs have microchips but it's a relatively low-up front cost with high returns. They can be helpful if someone from the public happens to take a LGD to the shelter, mistaking it for a domestic dog that has gotten loose. They typically cost around \$50.

- (41) [How Much Does It Cost to Microchip a Dog? \(2024\) – Vety](#) \$25-\$60
- (42) [Microchip Cost For Dogs – 2024 Guide – Forbes Advisor](#) \$50

Working Dog Liability Insurance (WDLI)

WDLI is an insurance made specifically for livestock producers who use LGDs or herding dogs for livestock protection and management. Policies start at an annual price of \$100 for the first LGD and often reduce significantly in price for each additional dog.

- (43) [How Much Does WDLI Cost? – Working Dog Liability Insurance \(WDLI\)](#)

Dog Food

The cost of dog food will ultimately vary from rancher to rancher depending on what variety of food they choose to feed their LGD, the breed of LGD and whether the dog is a puppy or an adult. LGDs tend to be larger dog breeds with very active lifestyles, causing their required

caloric intake to be high. (Costanzo, 2020) indicates that to maintain the weight of a 100 lb. neutered, working LGD, 5-6 cups of food a day is standard.

Assuming a daily requirement of 6 cups/day (1.88 lbs.), a requirement of 686.2 lbs. of dog food/dog would be required over the course of a year. According to some of the most popular dog food brands (linked below), commercial dog food typically goes for around \$1.67/lb.

686.2lb x \$1.67/lb. = **\$1,145.96/yr**

- (44) [Iams ProActive Health Adult Large Breed Dry Dog Food | PetFlow](#) (\$2/lb.)
- (45) [Purina Pro Plan High Protein, Digestive Health Large Breed Dry Dog Food, Chicken and Rice Formula | Pet Supplies Plus](#) (\$2.05/lb.)
- (46) [Pedigree High Protein Adult Dry Dog Food Beef And Lamb Flavor Dog Kibble, 44 Lb - Walmart.com](#) (\$0.96/lb.)

Shelter

LGDs often live with the livestock they protect, so available shelter will vary from situation to situation depending on how sheep/cattle are kept. This budget includes the general cost of a dog house made for larger dog breeds sold at Tractor Supply Co.

- (47) [livestock guardian dog houses at Tractor Supply Co.](#)

Miscellaneous \$200

The purpose of this category is to provide a safety net for any yearly expenses not included in the most obvious expenses that accompany owning a livestock guardian dog. For example, leashes, collars, food dispensers, additional vet expenses, etc.

Labor

For a LGD to be effective they must bond to their livestock while still a young puppy, typically between 8-16 weeks of age (Redden et al., 2015), (University of California Cooperative Extension, 2019). Although guardian dogs are bred to protect their stock, like any young animal, they need to be guided and observed. A good rule of thumb is that a LGD should not be unsupervised until the age of ~2. This budget sheet, like the previous ones, lists labor at \$20/hour. The budget sheet also lists labor hours for training time at 100 for a LGD at its puppy stage and is only meant to account for **active** time spent training that is taken away from other work/responsibilities. This includes familiarizing the puppy with livestock, other guardian dogs, operation perimeters and correct initial bad behaviors. This labor hour estimate is only a rough estimate of the training required for a LGD and subject to change by situation.

Disclaimer and other considerations:

This budget sheet is a best estimate at livestock guardian dog pricing, however with any animal comes a variety of health care costs. The risk of injury or death of a LGD is always present and unexpected medical costs can be incurred. Some state wolf depredation programs compensate for LGD depredation. There are also various insurance plans that potentially cover costs related to injury and death for working dogs.

Best practice also recommends having more than one LGD for the most effective outcome as LGD puppies often learn best from more established dogs. Additionally, two or more dogs can better work together to protect and mark territory. Another important consideration is that LGDs have a limited number of working years where they perform at their prime as both puppies and mature dogs do not have the same agility and working proficiency as a young adolescent dog.

INTERNET LINK KEY

LINK NUMBER	DISTRIBUTER	DIRECT LINK
Turbo Fladry		
(1)	Premier Supplies	Electric Fence Energizers - Premier1Supplies
(2)	Tractor Supply Co.	field-guardian-complete-grounding-kit-6-ft-900125 at Tractor Supply Co.
(3)	The Home Depot	6 ft. Complete Grounding Kit
(4)	Tractor Supply Co.	Red Brand 1,320 ft. x 170 lb. Galvanized Electric Fence Wire, 17 Gauge at Tractor Supply Co
(5)	Tractor Supply Co.	CountyLine 3/8 in. x 4 ft. Fiberglass Rod Post at Tractor Supply Co
(6)	Tractor Supply Co.	Patriot Rod Post Insulators, Yellow, 25-Pack at Tractor Supply Co
(7)	Uline	ULINE Search Results: Safety Fence T Post
(8)	Tractor Supply Co.	American Farm Works Screw-On T-Post Insulators for 1.25 and 1.33 in. Studded T-Posts, Yellow, 25-Pack at Tractor Supply Co
(9)	Tractor Supply Co.	Rubber Gate Handle at Tractor Supply Co
(10)	Amazon	Amazon.com: EFencSolv Electric Fence Mega Geared Reel PK1 : Patio, Lawn & Garden
Electrified Night Penning		
(11)	Farm Animal Report	Understanding How Much Room Does A Sheep Need - Essential Guide
(12)	Open Sanctuary	Creating A Good Home For Sheep - The Open Sanctuary Project
(13)	Family Farm Livestock	How Much Space Do You Need To Raise Sheep? – Family Farm Livestock
(14)	Tractor Supply Co.	Starkline 48 in. x 164 ft. Positive/Negative Electric

		Sheep and Goat Netting at Tractor Supply Co
(15)	Jeffers	Speedrite 3000 Dual Purpose Energizer, 3 joule — Jeffers
(16)	Tractor Supply Co.	Ghost Controls 30W Monocrystalline Solar Panel Kit with Brackets, No Post at Tractor Supply Co
(17)	Tractor Supply Co.	Ghost Controls Battery Box Kit with 2 Batteries and Harness at Tractor Supply Co
Range Riding		
(18)	IRS	IRS issues standard mileage rates for 2024; mileage rate increases to 67 cents a mile, up 1.5 cents from 2023 Internal Revenue Service
(19)	Conservation Northwest	Range Rider Pilot Project Conservation Northwest
(20)	My Patriot Supply	Frontiersman Bear Spray (9.2 oz) Deter Wildlife Attacks - Default Title - My Patriot Supply
(21)	Home Depot	Everbilt 8 ft. x 10 ft. Brown and Silver Heavy Duty Tarp PY008 - The Home Depot
Carcass Composting and Fence		
(22)	Home Guide	How Much Does a Concrete Slab Cost? (2025 Prices)
(23)	Agriculture Solutions	Agtec Heavy Duty Fast Response Compost Thermometer 36in (0-200°F)
(24)	Mytee Products	Agratronix Portable Hay Moisture Tester with Calibration Clip HT-PRO
(25)	Home Depot	Gorilla ToughLite 5/8 in. x 100 ft. Heavy Duty Garden Hose HYB55800 - The Home Depot
(26)	Tractor Supply Co.	Rain Bird Professional Grade Hose End Timer at Tractor Supply Co
(27)	Home Guide	2025 Well Drilling Costs Average Water Well Installation Cost

(28)	Kencove	KIWI S-Knot Woven Wire, 16/60"/2", 12 1/2ga, 200' Roll
(29)	Tractor Supply Co.	Gallagher Turbo Braid 1312 ft. Plus 328 ft. Extra 7/64in Diameter Highly Conductive Braided Poly Wire with SS and Copper Strands at Tractor Supply Co
(30)	Hull Forest	Bulk Sawdust Pickup & Delivery Prices Hull Forest Products
(31)	Hull Forest	Wood Chips for Biomass Fuel & Reactive Playground Surfacing Hull
(32)	River City Hardwoods	Retail Sawdust and Mulch Sales - River City Hardwoods
Livestock Guardian Dog		
(33)	USDA Wildlife Services	20220127_WS Nonlethal Initiative FY21 Annual Report Compressed Final.pdf
(34)	Willow City Farm	Livestock Guardian Dogs Willow City Farm
(35)	Estrela Mountain Dogs	Livestock Guardian Dog Breeder: Breeds Instinctive, Working LGDs
(36)	Dogster	How Much Does It Cost to Spay or Neuter a Dog? 2025 Price Guide – Dogster
(37)	Spend on Pet	How Much Does It Cost to Neuter or Spay a Dog? - Spend On Pet
(38)	Dogster	How Much Do Dog & Puppy Vaccinations Cost? (2025 Price Guide) – Dogster
(39)	Daily Paws	Dog Vaccinations Cost: What You'll Pay
(40)	Care Credit	Rabies Vaccine for Dogs: How Often Do Dogs Need Shots?
(41)	Vety	How Much Does It Cost to Microchip a Dog? (2025)
(42)	Forbes	Microchip Cost For Dogs – 2025 Guide – Forbes Advisor
(43)	Working Dog Liability Insurance	How Much Does WDLI Cost? – Working Dog Liability Insurance (WDLI)

(44)	Petflow	Iams ProActive Health Adult Large Breed Dry Dog Food PetFlow.com
(45)	Pet Supplies Plus	Purina Pro Plan High Protein, Digestive Health Large Breed Dog Food Dry, Chicken and Rice Formula - Pet Supplies Plus
(46)	Pedigree	Pedigree High Protein Adult Dry Dog Food Beef And Lamb Flavor Dog Kibble, 44 Lb - Walmart.com
(47)	Tractor Supply Co.	livestock guardian dog houses at Tractor Supply Co.