

Livestock Guardian Dogs: Do the Benefits Outweigh the Costs for Sheep Producers?

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We evaluate the economic viability of livestock guardian dogs (LGDs) as a tool to reduce predation of sheep by coyotes. Cost-effectiveness hinges largely on the ability of the dogs to eliminate coyotes as a threat, which is driven by site-specific factors. Our results suggest that the benefits of LGDs do not always outweigh the costs.

California has the second-largest sheep inventory in the U.S., but it has declined by 34% in the last two decades, more than double the national rate over the same period. Predation is a major threat to the economic viability of sheep production in California and one of the top reasons that producers leave the industry. In the U.S., coyotes pose a persistent problem, contributing over 50% of the total kills attributed to all predators. To combat these losses, ranchers have utilized an extensive suite of lethal and non-lethal tools to reduce predation. Both lethal and non-lethal tools are costly and require ongoing effort. All vary in efficacy and come with their own sets of challenges.

Many ranchers recognize the need to use both lethal and non-lethal tools in conjunction because lethal predator suppression methods are often insufficient in isolation. Suppression of a coyote population via lethal control for an extended period of time does not cause the total population to decrease. Coyote populations can rebound to pre-lethal-control densities within three to five years because reproductive success and pup survival improve when populations are lower. Plus, remaining predators quickly move into areas where lethal control has removed competition.

Public opposition to lethal control has also increased the pressure placed on

ranchers to adopt non-lethal methods. Concerned with livestock-predator conflicts and maintaining ecosystem diversity, some conservation biologists and animal rights activists have become increasingly vocal about their opposition to all available lethal depredation tools. As a result, certain jurisdictions, like Marin County, have discouraged lethal control and implemented programs to offset the costs associated with non-lethal tools. Yet, the elimination of lethal control reduces the flexibility with which producers can respond to the threat of predators, further threatening ranchers' economic viability.

Livestock guardian dogs (LGDs) are one of the most common non-lethal tools adopted by sheep producers and have generally been shown to be effective at reducing predation. However, their efficacy varies by the type of predator, terrain, and dog-to-ewe ratio. A lack of information surrounding the profitability associated with the adoption of different tools impedes ranchers' efforts to manage predation problems caused by wildlife. Despite the promise of LGDs, little work has been done to quantify the benefits associated with reduced predation via LGDs and compare these benefits to the costs in a comprehensive way.

We performed a comprehensive economic assessment of LGDs as a depredation tool using data from a University of California research station in Mendocino County, CA. We utilized detailed data collected over five years that allowed us to capture previously unknown components, such as the rate of lamb and ewe mortality, culling of LGDs, and labor hours associated with maintenance, allowing us to provide the first estimate of the cost-effectiveness of LGDs in the United States.

Study Location

The Hopland Research and Extension Center (HREC) is home to the University of California's sheep research flock. HREC maintains exceptional records along all three margins required for this study: the tagging and tracking of individual sheep, which allowed us to calculate reproductive rates and attribute losses to predators, detailed production data, including weights and market values that enabled the quantification of benefits of flock preservation, and, lastly, cost data on feed, veterinarian expenses, and labor associated with LGDs. We used HREC data spanning 2013 to 2017 to estimate the cost-effectiveness of LGDs on a representative commercial sheep operation of 500 breeding ewes with an average reproductive rate of 1.12 lambs per ewe per year.

Research suggests that a livestock guardian dog can provide protection for approximately 100 ewes in most settings. Thus, we modeled five LGDs on the representative operation. Based on these stocking rates, we compared the present value of expected future benefits (i.e., reduced lamb and ewe losses) with the present value of costs associated with investing in and maintaining LGDs. Future expected benefits and costs were discounted to the present at a rate of 3% over a seven-year period, the useful life of an LGD.

Estimated Benefits of LGDs

The main component of benefits associated with adopting LGDs as a depredation tool comes from the ewe and lamb losses that would have occurred in the absence of the LGDs. We estimated that the deployment of LGDs reduced lambs lost to coyotes by 43% each year at HREC. Given a representative breeding ewe flock of 500

Table 1. Timeline and Discounted Values (\$) for Components of Benefits and Costs from Using Five LGDs to Protect Lambs and Ewes

Components	Value							
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Benefits								
Reduced Lamb Predation	0	0	1,133	2,200	2,136	2,074	2,014	1955
Reduced Ewe Predation	0	0	461	896	870	844	820	796
Costs								
Investment	2,000	0	0	0	0	0	0	0
Food	0	3,170	3,078	2,988	2,901	2,816	2,735	2,655
Veterinarian	0	1,019	990	961	933	906	879	854
Replacement	0	133	123	135	79	78	85	94

Note: All displayed values have been discounted to the present at a rate of 3%.
Source: Authors' calculations

and reproductive rate of 1.12, LGDs are anticipated to reduce lamb predation by 27 head per year. During the study period, the average sale price for feeder lambs was \$1.37/lb and lambs were sold at an average weight of 65 lbs. Thus, savings from reduced lamb predation were estimated to be \$2,404 per year.

We also found that the deployment of LGDs corresponded to a drop in ewe predation of 25% per year, or four ewes each year on the representative operation. HREC sold running age ewes, i.e., females incorporated in commercial breeding flocks, for an average price of \$244.75 per head. The prices HREC received for these animals reflects the net (i.e., after cost) value of their remaining useful life as a capital asset, which includes producing lambs and wool, and their salvage value (i.e., value at the time of cull and slaughter). The estimated savings associated with reduced ewe predation totaled \$979 per year.

Given that LGDs are investments that have an average useful life of seven years, we must calculate all expected future benefits associated with LGDs over that time period with appropriate adjustments for the time value of money. The present value of the total anticipated savings associated with reduced lamb and ewe predation over

the seven-year horizon was estimated to be \$16,200, given our 3% discount rate.

Estimated Costs of LGDs

LGDs are considered capital investments that depreciate over time. In the initial period, the rancher faces the purchase costs, which vary by the breed and age of dog at the time of purchase. While puppies are less expensive to purchase initially, they involve substantially higher costs to train and are not effective immediately. For our analysis, we assumed dogs were purchased as puppies for \$400 each for a total initial investment of \$2,000 for five pups. We assumed these young LGDs were not effective at reducing predation in their first year and only 50% effective during their second year.

When calculating the costs, it is also necessary to include the risks associated with mortality and necessary culling of the LGDs. Evidence suggests that 45% of LGDs died or were put down during their useful life, with the risk being higher for pups. Assuming the mortality rate for each LGD in a given year was 11% if younger than 38 months and 5% if 38 months or older, then the present value of expected total replacement costs would be \$728, which is 36% of the initial purchase cost of \$2,000.

Maintenance costs for LGDs include dog food and veterinary expenses. Over the five years we observed at HREC, veterinarian costs averaged \$210 per dog per year and food averaged \$654 per dog per year. In total, the discounted present value of anticipated costs associated with using five LGDs as a non-lethal depredation tool over the investment's useful life totaled \$29,612.

Table 1 summarizes the different components that enter the benefit and cost calculations in each time period. The limited effectiveness of pups in their first two years are reflected by the lack of benefits realized in years 1 and 2. All displayed values are discounted.

Net Present Value

We estimated the discounted stream of future expected net benefits to assess the economic viability of investing in LGDs, illustrated by Figure 2, and found that costs exceeded benefits by a total of \$13,412 over the seven-year period. This translates to a benefit/cost ratio of about 0.55.

There are three important things to keep in mind when interpreting this result. First, HREC may have experienced lower efficacy rates than one may expect on the typical commercial sheep operation in the Western U.S. Past surveys on the effectiveness of LGDs have shown 68% of respondents reporting that LGDs eliminate predation entirely. In this scenario, a total of 65 lambs and 12 ewes would have been saved by LGDs from coyote predation, relative to the pre-control baseline. Thus, savings from reduced lamb and ewe predation would be \$5,788 and \$2,937 per year, respectively. Under these conditions, the present value of benefits would exceed the costs by \$12,164 over the seven-year period, equivalent to a benefit-cost ratio of 1.41.

LGD effectiveness is dependent on a number of site- and operation-specific

factors including size of pasture, changes in elevation, tree cover, perimeter fencing, ewe-to-LGD ratio, and the discount rate. In order to enhance the potential efficacy of LGDs, producers may need to make changes to other aspects of their operation, which may have additional costs. LGD ability and efficacy also depend on genetics and training. As noted, many dogs do not have the temperament or proclivity for protection and need to be culled. Thus, producers considering incorporating dogs onto their operations need to include the likely costs associated with cull and mortality when considering this investment.

Second, labor-related expenses are an important and variable cost component that can be tricky to quantify. If caring for LGDs is easily incorporated into a rancher's daily activities, then labor costs may be minimal. At HREC, however, reported labor costs averaged \$1,584 per dog per year. But given that these data come from a University facility, employee wages and benefit rates are likely to exceed those a ranch operator would attribute to his own time and effort. Inclusion of labor costs would decrease the benefit/cost ratio.

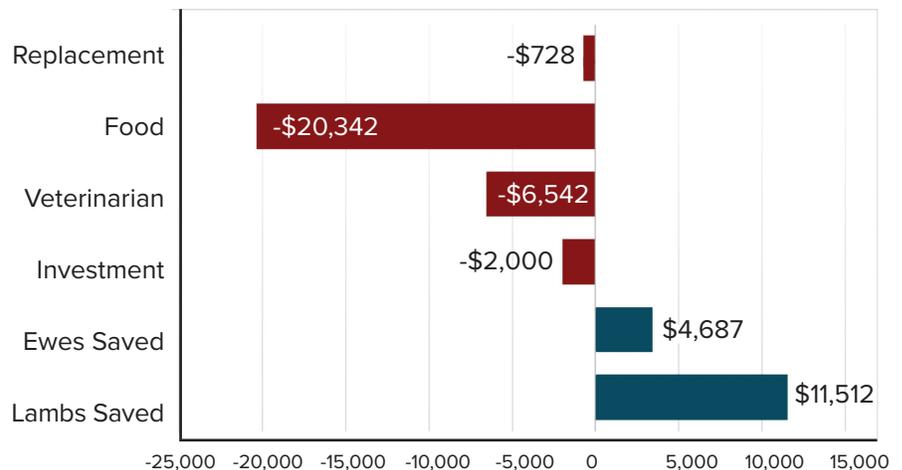
Finally, these results are dependent on other changing factors, such as the lamb and ewe sale prices. We derive the benefits of reduced predation from average sales prices for lambs and ewes, which vary from year to year. To the extent that prices change dramatically over time, so too will the value of the services that LGDs are anticipated to provide.

Management Implications

Predator control is a necessary component of sheep production. Lethal control faces public resistance and cannot always cause persistent impacts to predator populations, but the economic implications of adopting non-lethal tools are not yet well understood.

LGDs have been shown to decrease and, in some cases, eliminate sheep

Figure 1. Net Present Value of Expected Benefits and Costs from Using Livestock Guardian Dogs to Protect Lambs and Ewes



Note: Values are shown for a representative flock of 500 breeding ewes with five LGD that achieve reductions in lamb [ewe] predation of 43% [25%]. Costs are in red and benefits in blue.

Source: Authors' calculations

predation by coyotes. However, it is important to recognize that the costs associated with the purchase and maintenance of LGDs may outweigh the benefits for certain sheep operations. Results from this study, calibrated from data at HREC, showed that the benefit/cost ratio was 0.55, i.e., the benefits of LGDs did not cover the costs, despite valuing additional labor costs associated with dog management at zero.

Sheep producers who are considering the purchase of LGDs, or those who already have LGDs and are interested in their return on investment, need a few pieces of data to make this determination. Market lamb and ewe prices are typically well known to producers and can be used, in conjunction with efficacy rates from this study, to estimate the benefits of LGDs.

On the cost side, producers would need to make some logical forecasts about the time required to maintain LGDs, given their operation specifics. The costs associated with food and veterinary maintenance from this study could serve as a reasonable forecast for these costs on commercial operations. Also, using guidance from the literature included herein, producers could calculate the likely dog cull and mortality costs over the LGD's useful life.

Finally, an operator-specific discount rate should be chosen. Combining these pieces of information would provide a producer with estimated benefit and cost information critical to their investment decision and economic viability.

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For additional information, the authors recommend:

Macon, D., et al. 2018. "Livestock Protection Tools for California Ranchers." University of California, Agriculture and Natural Resources Publication 8598. <https://anrcatalog.ucanr.edu/pdf/8598.pdf>