**Cover page**

A. June 30, 2022
B. Evaluating the Effects of Livestock Guardian Dogs on Wildlife Species
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E. Project location: Rangeland west of Auburn, California (Placer County) and grazing allotments within the Tahoe National Forest (Sierra County)
F. Applied Research
G. Supporting Farmers & Ranchers
H. Livestock
I. $6,704.4

## II Objectives

1.1 Examine if there is a difference in the use of grazing areas versus nongrazing areas by target and nontarget species

2.1 Examine the effectiveness of LGDs in protecting sheep in relation to carnivore presence

2.2 Examine LGD movements in relation to the movements of sheep they are guarding, to roads, and for Study Site 1, to fences. Document any known negative interactions between LGDs and recreationists.

*We chose not to include roads as a variable in the Tahoe grazing area because given the high density of game trails and recreational activity occurring off of roads, roads did not appear to be a relevant variable.*


## Summary

Rangeland livestock operations in California often rely on the same habitats used by carnivores that predate on domestic sheep and can significantly impact the economic viability of livestock production. These conflicts are often intensified by public policy and perception that limit lethal predator control options for livestock. Consequently, producers are increasingly turning to a variety of nonlethal livestock protection tools, including livestock guardian dogs (LGDs), to protect their herds from predators. Despite the increasing use of LGDs, very little is known about LGD behavior and the direct and indirect interactions of LGD with carnivores and other wildlife species. This project aimed to examine if LGDs have their own environmental cost to the environment through their interactions with wildlife and how far LGDs range from their livestock in fenced or unfenced pastures, which relates to the potential for conflict with recreationists.

We conducted research in two study sites—1) Grazing allotments in the Tahoe National Forest ("Tahoe"), where sheep were accompanied by a herder and grazed on open rangeland without fences and 2) Rangeland west of Auburn ("Auburn"), where sheep were rotationally grazed within portable electric net fence. Within each study site, we classified areas as grazing or nongrazing, and placed game cameras within each area. Cameras collected data on wildlife before, during, and after the sheep and LGDs were in the grazing area. In addition, we fit GPS collars onto sheep and LGDs to track their movements.

We recorded coyote, bear, and bobcat in the Tahoe grazing area and mountain lion, coyote, and bobcat in the Auburn grazing area. Despite the presence of these species, no sheep were lost to predators. In addition, we did not record any negative interactions between LGDs and recreationists. LGDs remained close to the sheep (within 400m) for at least 77% of the time. Across study sites, we found LGDs had a median distance to sheep of less than 80 m (ranged from 59 to 79 m).

We did not record any injured wildlife in the Tahoe site, despite recording fine scale overlap between LGDs, coyotes, and bears. In the Auburn site, however, we recorded one raccoon killed by an LGD and one lamb was either stillborn or killed by an LGD. Those results demonstrate the potential negative aspects of LGD deployment, though the fact that it was the same individual LGD that was found with both the lamb and raccoon may be more of a reflection of variance in individual LGD behavior than LGDs in general.

Statistical analyses of the camera results are currently underway and those, paired with our next year of data collection, will help inform any potential difference of LGD impacts on wildlife between grazing systems. This information will have important implications for land managers who may be considering the use of LGDs and want to optimize for minimizing potential impacts to wildlife. We hope the continuation of this research will further assist in understanding the tradeoffs associated with reducing the need for lethal control of predators.

**Specific Results**

*1.1 Examine if there is a difference in the use of grazing areas versus nongrazing areas by target and nontarget species*

We deployed game cameras in grazed and ungrazed areas of each of the two study sites (Table 1, Figs. 1 and 2). For the Tahoe study area, where there were no fences, we placed "grazing area" cameras where we assumed sheep would feed and nearly all cameras captured sheep. For the Auburn study area, in which sheep were rotationally grazed within portable electric net fence, we placed "grazing area" cameras either within pastures or directly adjacent (within 100 m) to grazing pastures.

For the Tahoe study area, the number of cameras deployed in ungrazed areas was limited by feasibility in access and geographic scope of grazing areas used by sheep bands not part of the study. For the Auburn study area, we deployed the maximum number of cameras that would fit in the 2022 grazing area given our study design of one camera per 1 km x 1 km grid cell.

Table 1. The total number of game camera deployed in grazed and ungrazed areas of each of the two study areas.

| | **Number of cameras deployed in:** | |
|---|---|---|
| **Study Area** | **Grazed Area** | **Ungrazed Area** |
| Tahoe | 16 | 12 |
| Auburn | 5 | 5 |

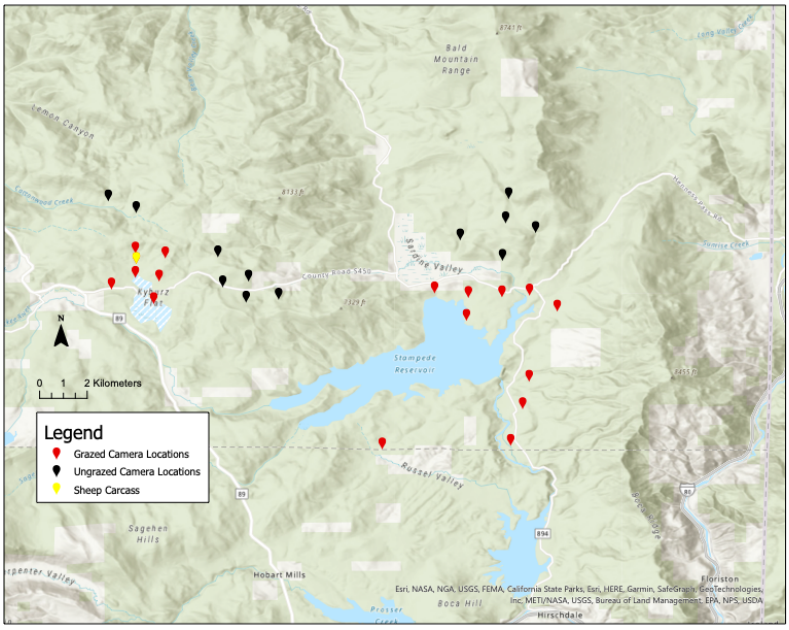


Fig. 1. Locations of cameras deployed in grazed (red) and ungrazed (black) areas of the Tahoe study area. The location of the camera facing the sheep carcass is in yellow.

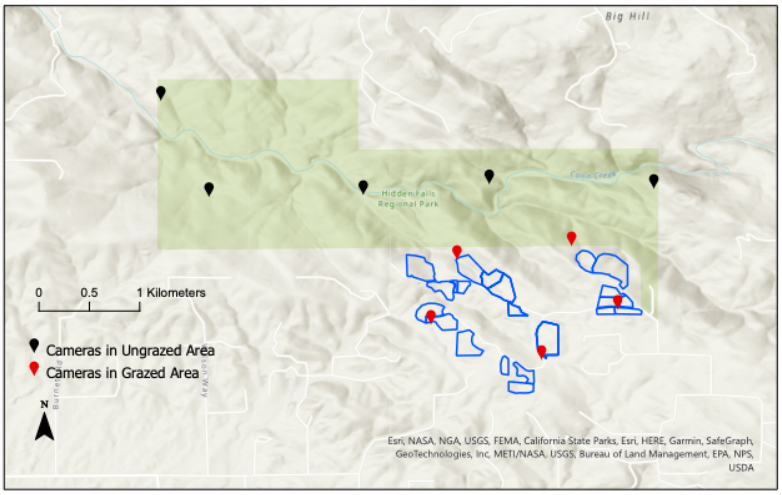


Fig. 2. Locations of cameras deployed in grazed (red) and ungrazed (black) areas in relation to sheep pastures (in blue) in the Auburn study area.

See Tables 2, 3, and 4 for a preliminary summary of the camera results. A more detailed statistical analysis is in progress (delayed due to PI starting maternity leave while data collection was still in progress). We will be using occupancy modeling to examine the following:

1. Is there a significant difference in capture rate per species in grazed versus ungrazed areas for each study site?
2. Is there a significant difference in capture rate per species before, during, and after LGD presence within each study site's grazing area?

Table 2. The total number of camera captures per species per period within the grazed area of the Auburn study site. Note that the number of trap days varies per grazing period.

| GRAZED AREA | Coyote | Deer | Gray fox | Bobcat | Skunk | Mountain Lion |
|---|---|---|---|---|---|---|
| **Before (200 trap days)** | 15 | 43 | 16 | 4 | 0 | 0 |
| **During (645 trap days)** | 31 | 139 | 47 | 6 | 37 | 1 |

Table 3. The frequency of camera captures per trap day per species within the grazed area of the Auburn study site.

| | Frequency of camera captures per trap day | | | |
|---|---|---|---|---|
| | **Coyote** | **Deer** | **Gray fox** | **Bobcat** |
| **Before LGD presence** | 0.08 | 0.22 | 0.08 | 0.02 |
| **During LGD presence** | 0.05 | 0.22 | 0.07 | 0.01 |

Table 4. The total number of camera captures per species per period ("Before", "During", "After" LGD presence) within the grazed area of the Tahoe study site.

| | Bear | Deer | Bobcat | Coyote |
|---|---|---|---|---|
| **Before** | 2 | 77 | 2 | 39 |
| **During** | 2 | 47 | 5 | 32 |
| **After** | 4 | 38 | 0 | 28 |

*2.1 Examine the effectiveness of LGDs in protecting sheep in relation to carnivore presence*

We recorded coyote, bear, and bobcat in the Tahoe grazing area and mountain lion, coyote, and bobcat in the Auburn grazing area. Despite the presence of these species, no sheep were lost to predators during the two study periods in either study site. In the Auburn study area, a LGD was found with a dead lamb, but we could not confirm whether it was a stillborn or if the LGD killed it. The LGD found with the dead lamb was three years old but this was the first time he was in with a lambing ewe—during the rest of the 2022 lambing season, he was kept elsewhere.

In the Tahoe study area, one adult sheep was lost to an unspecified illness, providing a unique opportunity to study the behavior of scavengers and the impacts of carcass near sheep bedding grounds. We placed a game camera on the carcass for 8.5 days. Interestingly, over that time period we recorded coyote, livestock guardian dogs, herding dogs, turkey vultures, and bear. We recorded fine-scale temporal overlap between LGDs and predators, with coyotes approaching the carcass merely 11 minutes after the camera recorded an LGD, and a bear and LGD being recorded less than one minute apart. Despite this overlap and the carcass acting as an attractant for predators, no LGDs were injured and no additional sheep in the band were lost to any kind of mortality event.

*2.2 Examine LGD movements in relation to the movements of sheep they are guarding, to roads, and for Study Site 1, to fences. Document any known negative interactions between LGDs and recreationists.*

Preliminary data analysis for the Tahoe study area suggests an effect of sheep-LGD distance and the time of day but we are currently working on running generalized linear mixed models to further examine that relationship and to test for significance.

For the Tahoe study area, we deployed GPS collars onto three sheep and four LGDs as they were turned out onto the pasture. Unfortunately, we encountered unanticipated challenges with the GPS collars. One GPS collar fell off of an LGD and was lost. In addition, the batteries on all collars did not last as long as expected and we were unable to re-catch any sheep during the grazing season to deploy new collars or replace the battery. The GPS collars did collect 7.5 days-worth of data for sheep and that was used for analysis. We were able to replace the collars on the LGDs fairly regularly, and we have LGD movement data for nearly the entire grazing season.

After we discovered that those GPS collars weren't going to be sufficient for our purposes, we regrouped and switched to a different brand ((Digital Matters Oyster collars). When the new collars arrived, we deployed them on LGDs and sheep in the Auburn study site as a test. The battery life and functionality of the new collars was a vast improvement and we will be deploying these new collars going forward. We will be fitting them on sheep and LGDs in the Tahoe study site in July 2022 for the continuation of this project.

From the collar data we were able to collect in the Tahoe study area, a preliminary analysis using hourly fix rates showed few instances when dogs were further than 500m from sheep during the day. All but one instance when the LGD was very far (over 1km) from sheep occurred at night. The mean and median distance between sheep and LGD was 318 m and 79 m, respectively, for one LGD and 176 and 70 m, respectively, for the second LGD used in the analysis. One LGD remained within 400m of the sheep 77% of the time and ranged more than 400 m from the sheep primarily at night. The other LGD remained within 400m of the sheep 89% of the time and mainly ranged far from the sheep during the day. Thus overall, the potential for negative interactions between LGDs and recreationists out of sight of the herder was low.

For the Auburn study area, we conducted an analysis of distance between sheep and one of the LGDs ("Elko") using fixes at 15 min intervals. The analysis showed the LGD remained within 400 m of the sheep 94% of the time, within 300 m 82% of the time, and within 200 m 52% of the time. Mean and median distance between Elko and sheep was 64 and 59 m, respectively. Interestingly, despite one study area having fences and the other being open rangeland, the LGDs used in the preliminary analysis had similar median distances to sheep (ranging from 59 to 79 m).

We did not record any negative interactions with recreationists in either study area. We did conduct an informal test where Whitesell took her leashed dog within 100 feet of the Truckee herd during midday and it did not elicit any reaction from the LGDs.

In addition, the herder in the Tahoe study area did not report any instances of the LGDs harming wildlife. In the Auburn study area, however, we did record one instance of an LGD killing a raccoon within one of the fenced grazing pastures. The LGD found with the dead raccoon was the same LGD that was found with the dead lamb.

The Auburn study area encompasses a system of rotational grazing in small pastures enclosed by electric net fencing. This fencing presumably keeps LGDs within the pasture while physically excluding wildlife. When planning and conducting this study, we designated the Auburn study site "grazing area", "During" time period as the entire time when sheep and LGDs were present in the area. When deploying the cameras, some were placed in areas that were eventually fenced off within a pasture whereas others were placed no more than 100 meters of a fenced pasture but weren't themselves ever within the fence. Camera 53 was encompassed within a grazing pasture for approximately five days. The results of this camera generated interesting questions regarding potential impacts of LGDs on wildlife at an extremely fine spatial scale within a temporarily fenced pasture. When zooming in and reframing the time periods "Before" and "During" solely in relation to when the camera was within the fence, we noted the following:

Prior to the camera being fenced off, it captured regular gray fox visits but zero skunk visits. When the camera was fenced within the grazing pasture and for four days afterwards, no photos of wildlife were captured. Then the first skunk was recorded, and over the next month skunk visited the camera 12 times. The first gray fox returned to the camera within eight days after the sheep were moved and the camera proceeded to capture gray fox at a nearly identical frequency as before the sheep arrived. When considering deer, prior to the camera being fenced, it recorded 15 deer over 40 days (median interval before deer visits was 1.5 days). After the sheep left, no deer were recorded for 58 days. While skunk appeared to be attracted to the pasture after sheep and LGD presence, there did not appear to be any shift in gray fox movements other than when the camera was fenced off, and deer appeared to have avoided the area after the sheep and LGDs. Further investigation is warranted to explore if the patterns captured by this camera represent any true impact of sheep and LGD on wildlife movements or not. Targeted rotational grazing with sheep (paired with LGDs) is a fire abatement strategy and as this tool continues to be used, it is important to understand its potential impact on fine scale wildlife movements within the pasture itself, not only in the general grazed area. During the continuation of this project, future placement of more cameras directly within each fenced grazing pasture will assist in better examining these potential patterns.

While we did face unexpected challenges in some aspects of data collection, overall, we were successful in collecting the necessary data to examine our objectives and will be applying lessons learned as we launch our next season of data collection in the Tahoe study area.

**Dissemination of Findings**

Throughout fieldwork, game camera photos from the project were shared via Social Media. Updates on the project were given at a workshop on livestock guardian dogs and at San Mateo County Farm Bureau meetings. Observations were also shared via the Ranching in the Sierra Foothills blog. When the statistical analyses are complete, we will be presenting this research at the next Vertebrate Pest Conference and will be writing articles on the results to publish on the UC ANR website, in the UCCE San Mateo County quarterly newsletter, in the CA Farm Bureau newsletter and the CA Woolgrowers Association publication.

**Benefits/Impacts on Agriculture**

Our research further demonstrates the effectiveness of LGDs in protecting sheep within open rangeland and fenced systems in areas with confirmed predator presence. The recorded loss of a lamb and a raccoon also demonstrate the potential negative aspects of LGD deployment. The fact that it was the same individual LGD that was found with both the lamb and raccoon may be more of a reflection of variance in individual LGD behavior than LGDs in general. The results of the statistical analyses of the data collected by this project, combined with our next year of data collection, will help inform any potential difference of LGD impacts on wildlife between an open rangeland system versus a fenced rotational grazing system. This information will have important implications for land managers who may be considering the use of LGDs and want to optimize for minimizing potential impacts to wildlife. Does one management system better minimize those impacts? We hope the continuation of this research will shed further light on the frequency and scope in which these negative impacts on wildlife may occur in different grazing systems within California. This is critical information for understanding the tradeoffs associated with reducing risk to livestock and reducing the need for lethal control of predators.