The Marin County Livestock Protection Program: 15 Years in Review

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ABSTRACT: In 2001, Marin County, California, replaced its USDA Wildlife Services (WS) cooperative predator damage management program with a county-run program that emphasized non-lethal methods for preventing and controlling coyote predation on sheep. This new "Livestock Protection Program" cost-shared with livestock producers' efforts to improve fencing, obtain and maintain guard animals, and other such non-lethal methods, and initially it compensated producers for documented losses to predators. We surveyed sheep producers in Marin County in an effort to review the program over the past 15 years, evaluating the program in relation to livestock production, economics, predation management, and other measures of producer satisfaction. Lack of standardized data collection during the current program complicates its evaluation; however, from available information, we conclude the number of sheep and lambs are being produced in Marin County has continued to decline; some producers left the sheep business and other who remain graze less acreage with smaller flocks; predation by coyotes remains a high concern to producers; and most producers are dissatisfied with the Livestock Protection Program.

KEY WORDS: *Canis latrans,* coyotes, damage assessment, economics, livestock predation, Marin County CA, non-lethal methods, predator control, predation loss, sheep and lamb loss, survey, USDA Wildlife Services

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INTRODUCTION

Predation, particularly by coyotes (*Canis latrans*), has been an increasing problem for sheep producers in California's north coast region (Larson and Salmon 1988, Timm and Connolly 2001, Larson 2006). Even when employing all legal and available methods, including both non-lethal and lethal strategies, loss of sheep and lambs to coyotes was one of the main reasons for producers going out of the sheep business (Larson and Salmon 1988). Over time, this led to a long-term decrease in total sheep numbers, with steady declines in both Sonoma and Marin Counties (Figure 1).

During the 1970s and 1980s, sheep ranchers in Sonoma and Marin Counties suffered few losses from predators in comparison to those in inland areas of California's more northern coastal counties (i.e., inland Mendocino and Humboldt Counties). Through time, coyotes expanded their range and became more numerous in Sonoma County while moving southward into Marin County (Figure 2). Sheep and lamb losses began to occur by the mid-1980s, and the problem continued to spread and increase (Larson and Salmon 1988, Larson 2006).

To help reduce predation losses, in the late 1980s, Marin County began a cooperative animal damage control agreement with the California Department of Food and Agriculture and the U.S. Department of Agriculture APHIS Wildlife Services (USDA WS), which provided professional assistance from a wildlife specialist. During much of the 1980s and 1990s, methods used on sheep ranches in Marin County to control coyote predation included traditional lethal methods such as calling and shooting, leghold traps, snares, as well as den hunting and removal of pups. Non-lethal techniques used by producers included conventional and electric fencing (cross and perimeter), placement of lambs or sheep near areas of human activity, use of herders, and in some cases, gathering livestock at night. By the 1990s, use of guarding animals such as dogs and llamas had become more prevalent. Electric fencing and use of herders was found to be effective, while use of night pastures was not found effective by some who tried it (Larson and Salmon 1988). For producers who chose to request assistance from the USDA WS specialist, certain tools and materials available only to Wildlife Services could also be used on their property: M-44 sodium cyanide ejectors, and the Livestock Protection Collar (following its registration in California early 1996) (Timm et al. 1997, Larson 2006). The USDA WS specialist preferred the leghold trap because non-target species were at low risk of serious injury or death, allowing most captured non-targets to be released (pers. comm., George Alfonso, former Marin County WS Specialist). Subsequently, voter approval of California's ballot initiative ("Proposition 4") in November 1998 banned the use of leghold traps (except in human safety emergencies) as well as the active ingredients used in the M-44 and in the Livestock Protection Collar (Timm and Connolly 2001, Animal Legal & Historical Center 2006). Thus, removal of problem coyotes came to rely primarily on calling and shooting, and to a lesser extent, snares. Landowners were still able to remove coyotes from their property by using any method legally available to private citizens.

Marin County's Livestock Protection Program

In late 2000, the Marin County Board of Supervisors decided to replace the Wildlife Services program with a county-administered predator management program

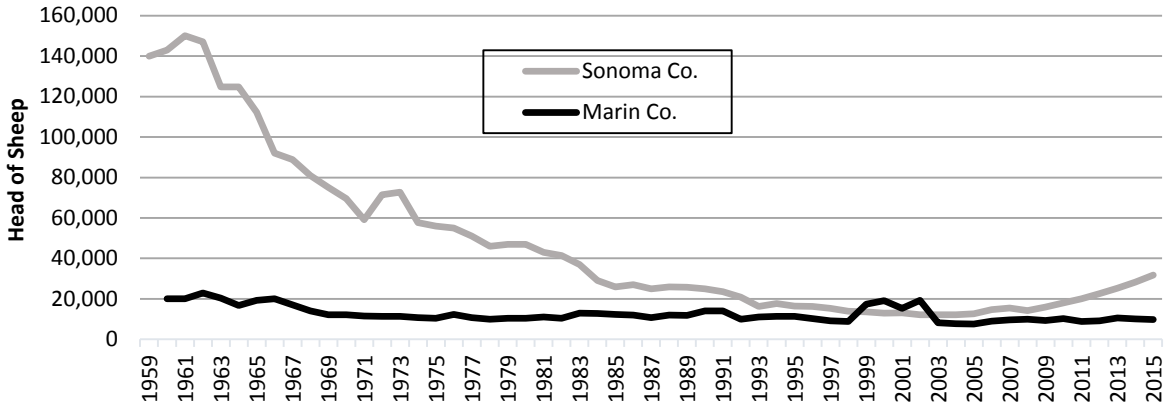

Figure 1. Sheep numbers, Sonoma & Marin Counties, California (Marin County 2016, Sonoma County 2016)

Figure 2. Sonoma & Marin Counties, California, in relation to adjacent Bay Area counties.

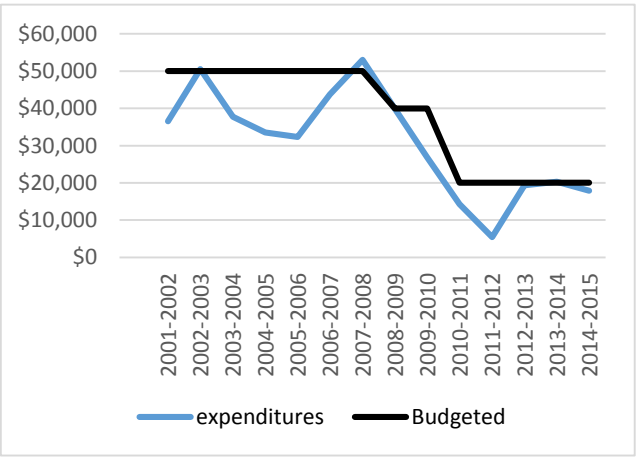

Figure 3. Annual Marin County, California, budget vs expenditures for the Livestock Protection Program.

supervised by the County Agricultural Commissioner's office. This program is described elsewhere as Marin County's "Ranch Improvement/Non-lethal Control and Indemnity Plan" (Shwiff et al. 2005, 2006) but is known locally as the "Livestock Protection Program" (LPP). Through this program, qualified ranchers could request funding to assist in the implementation of non-lethal management methods (e.g. fencing improvements, guard animals, scare devices) to attempt to reduce coyote depredation. This program became effective during the county's 2001-2002 fiscal year (beginning July 1, 2001). In actuality, the WS program ceased operation in Marin County on December 1, 1999, when the WS Specialist position became vacant.

To participate in the new county-administered predator program, ranchers needed to utilize any combination of four categories of methods to deter predation: 1) new fence construction or improvements to existing fences; 2) guard animals (dogs and llamas); 3) scare devices; and 4) changes in animal husbandry, including shed lambing, use of herders, and other techniques. Initially, for each method, a rancher could receive a cost-share payment of $500 per practice up to a maximum of $2,000 annually. Producers also qualified for compensation for livestock lost to predators (market price per head lost) upon instigation of at least two of the four categories, subject to inspection and verification.

In the beginning, 17 producers were introduced to the LPP, working with Agricultural Commissioner and University of California Cooperative Extension (UCCE) staff, and 13 producers enrolled (pers. comm., S. Carlsen, Marin Co. Ag Commissioner). Two producers specifically chose not to be involved in the LPP because they did not support the premise of the LPP. While many participating producers didn't support the LPP (Larson 2006), they perceived it was essentially their only option to continue sheep production in Marin County. Participating producers gave more emphasis to non-lethal tools, trying many of the different program criteria to remain in business (Larson 2006).

Despite an initial annual budget of $50,000 from Marin County, funding for the LPP has declined dramatically since its inception (Figure 3). In addition, producer participation declined due to lack of program acceptance, exces-

sive lamb losses to coyotes, and decreased revenue, resulting in some producers changing from sheep production to cattle. In later years, when Anita Sauber's duties changed and following her subsequent retirement in 2013, producers felt dissatisfied with the program due to reduced communication with Agricultural Commissioner staff, (pers. comm., Anita Sauber, Marin Co. Ag Commissioner staff). To increase participation, the LPP was expanded beyond sheep to include poultry in 2008 and cattle (both beef and dairy) in 2012.

At the beginning, the LPP compensated all losses from coyote depredation, paying market value for the animals lost to predation. The Marin County Agricultural Commissioner's staff and UCCE personnel verified sheep and lamb losses due to coyotes. At the end of the fiscal year; producers completed a Livestock Protection Program Cost Share Reimbursement and Indemnification (losses) form, working with the Marin County Agricultural Commissioner staff. By the third year of the program (2003), the compensation payments were capped at 5% of the total ewe herd; e.g. producers with a 200-ewe flock could be reimbursed for a predation loss not to exceed the market value of 10 ewes. A self-monitoring system followed, where producers called losses into the Commissioner's office and also emailed a monthly loss summary card to the UCCE office. The card verification ended in 2005, replaced by an annual document that producers signed in June, stating the number of sheep lost to predation, and producers were compensated for losses of up to 5% of their ewe flock, based on market rate of animals lost.

METHODS

Agricultural Commissioner

We received all available data on the Livestock Protection Program including number of participants, costs, results, and any evaluations conducted by that office, for the period from 2001 to 2015, after an email request was sent to Jeff Stiles (Marin County Agricultural Commissioner staff).

Producer Survey

A survey (Appendix A), which was modeled after the instrument used by Fox (2008), was created to assess the LPP 15 years following initiation of the program. Approved by the University of California-Davis Internal Review Board, the survey included a pre-addressed reply envelope and was mailed to 19 producers who we identified as having raised sheep in Marin County during the period 2001-2015 and who participated in the LPP: 13 were still in the sheep business (13), and 6 were no longer in the sheep business. The totals represent all producers known to the senior author Stephanie Larson and/or participating in the LPP (pers. comm., Jeff Stiles, Marin County Ag Commissioner staff).

Survey responses were anonymous, although respondents were given the opportunity to include their name and a request to speak directly with the senior author. Four producers who completed the survey indicated an interest in discussing the LPP, and the senior author met directly with each of them. Authors also met with four producers who did not complete the survey but had been in the LPP. We interviewed them, soliciting survey data relevant to their history, including reasons they ceased sheep production.

Producer Meeting

A producer meeting was held in February 2016 to allow producers to openly discuss the LPP, including their satisfaction, concern, and suggestions for changes to the LPP. Producers were invited by personal letters from the senior author, Stephanie Larson, and by the Sonoma County Wildlife Services Specialist, Jeff Furlong. The meeting was attended by 14 Marin and Sonoma County sheep producers. Sonoma County producers were present because they also run sheep in Marin County and were involved in the LPP. The survey, producer meeting, and individual producer interviews all provided information to assess the level of participants' satisfaction with the LPP.

Statistical Analysis

We calculated an agreement index and estimates confidence intervals for responses to each Likert-style question following a procedure implemented in the R statistical environment (McGranahan et al. 2017). This method provided inference into two aspects of the responses: whether a trend towards positive or negative responses can be considered significantly different than zero, as well as the magnitude, or strength, of the response. Calculating the index began with an effect size for the difference between the observed data and the null expectation (i.e., an equal number of responses across all categories) based on multinomial distributions as in the EMT package for the R statistical environment (Menzel 2013). This effect size was then multiplied by the mean response (as in R package likert; Bryer and Speerschneider 2016), which has been scaled so that negative responses got a negative sign, positive responses were positive, and ambivalence or no opinion was made to be zero. The 95% confidence intervals were calculated from 1,000 simulations of the observed data.

RESULTS and DISCUSSION

Change in Program Participants & Livestock Numbers

In FY2001-2002, the Livestock Protection Program began with 13 sheep producers participating, and it increased to a total of 17 producers in the next three fiscal years (Larson 2006), reaching a peak of 22 producers in FY2008-2009. Fox (2008) stated there were a total of 18 sheep producers participating in the LPP as of November 1, 2006. The participating producer numbers increased in subsequent years because poultry, beef, and goat producers were included in the program.

In FY2014-15, the LPP participation covered 3,782 sheep, 10,800 poultry, and 40 calves (owned by a single participating producer) (email comm., Jeff Stiles, Marin County Ag Commissioner staff). Currently, sheep numbers in Marin County are listed as 10,000 in the County's annual Crop Report (Marin County 2016); if this estimated is accurate, then only 38% percent of the total sheep in Marin County are enrolled in the program.

As of the beginning of 2016, we believe the total number of viable sheep producers in Marin County (with ≥200 head of sheep) is fewer than 10 and that number continues

to decline (pers. comm. with local producers). However, during the past decade, the number of smaller-scale producers (<200 head) has increased, with approximately 6 producing milk for specialty cheeses. These new milk sheep operations tend to be on small properties where sheep are generally more confined, thus not likely subject to coyote predation.

Since the Program's inception, several sheep producers in Marin County have gone out of business. Some passed away and their heirs chose not to continue in the sheep business, while others went into the cattle business because they could no longer remain profitable with sheep. At least one producer was unable to maintain viable businesses due to increased predation losses and/or the inability to implement two of the four required categories of non-lethal measures. In our interviews, several producers stated predation was exacerbated by brushy or steep terrain, large acreage sizes, and inability to secure long-term leases. All of these factors made use of many non-lethal strategies difficult or ineffective: guard animals cannot be effective when they cannot see what is happening within a pasture because of topography or brushy vegetation; installing or improving fencing in large pastures so as to completely exclude predators is expensive, and would not be considered by a rancher on leased pasture.

Survey Response Rate

Of the 19 surveys we sent to sheep producers, 11 surveys were returned, a 58% return rate. Cattle and poultry producers currently participating in the LPP were not surveyed, as they were not in the program at its inception. As noted above, 4 producers who received but did not complete the survey, because they were no longer raising sheep, contacted us and agreed to be interviewed. When these individuals were also considered respondents, our response rate to the survey was 15/19 (79%).

Cost-Share and Compensation Payments for Predation Losses

When the LPP began, the Marin County Board of Supervisors allocated a total of $50,000 for distribution to participants once they met program qualifications. This amount was to cover both the cost-sharing for non-lethal tools as well as the compensation payments for predator-caused losses. Figure 4 shows the amount of monies paid for cost-share. In the LPP's beginning, qualified livestock producers with >200 head of sheep were paid $2,000, and those with <200 head received $500 annually. In 2008, the amount was raised to $2,500 and $700, respectively. When the compensation component was removed (2009), the cost-share amounts were increased so that producers with ≥300 sheep received $3,000 and those with <300 head received $1,500 annually. Poultry producers with numbers of 450 or more birds and cattle producers received $1,200. Figure 4 totals the annual cost-share and compensation payments from 2001-2015. In 2011-2012, only three producers were paid for cost-share ($2,500 total) while three (including one of the cost-share producers) were compensated for losses ($2,900 total).

The County's annual cost has ranged from a low of $5,400 in FY2011-2012 to a high of $50,354 in FY2002-2003. The average annual cost to the county for the LPP

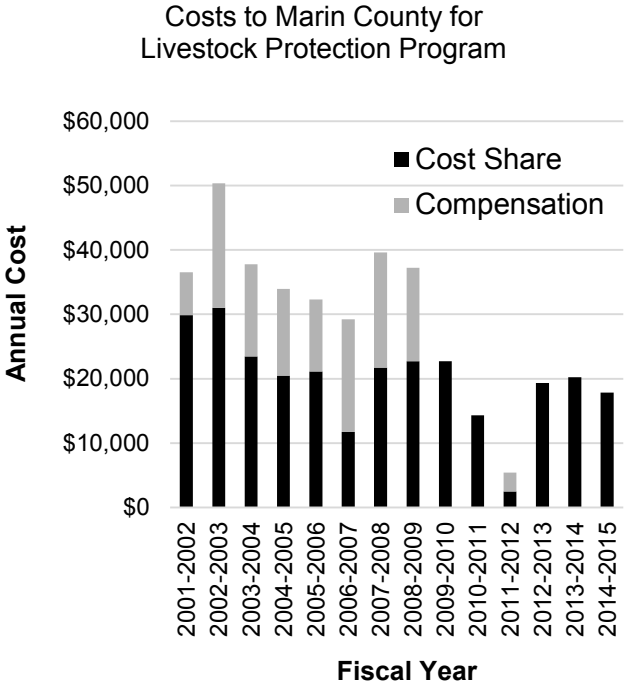

Figure 4. Livestock Protection Program cost-share and compensation payments, FY2001-2002 through FY2014-2015. (Data provided by Marin County Agriculture Commissioner's office)

from FY2001-2002 through FY2015-2015 was $28,349. The 5 years prior to the LPP, the county's annual contribution to the USDA WS program averaged $21,230. Thus, the LPP's average annual cost has been 1.3 times the cost of the Wildlife Services program (Table 1); this does not take into account the federal funds provided by USDA WS that were "left on the table" by eliminating the Wildlife Service program, nor is it adjusted for inflation.

Fox (2008) stated the cost-benefit analysis commissioned by the USDA WS in 2005 (Shwiff et al. 2005: preface, p. iv), in which a cost comparison was made between the two programs, was rife with unscientific assumptions. The claimed "replacement value" assumption used in that analysis assumes that costs of replacing USDA WS would continually increase based on an assumed projection of increased livestock losses, as was shown in our survey results. Shwiff et al. (2005) concluded that the USDA WS program is more cost effective; Fox (2008) stated that the authors provide no evidence to support this assumption. We note that the cost of the LPP would have been greater if the compensation program had not been capped at 5% in 2005 and subsequently eliminated; based solely on producers' reported losses, costs to the county would have been thousands of dollars more.

Initially, most of Marin County's sheep producers opposed the termination of the existing predator control program and they felt their views were not given adequate weight by the County Board of Supervisors (Larson 2006). Currently, the only a small percentage of the original producers that participated in the LPP are still in the program

Table 1. Estimates of livestock killed, coyotes and non-targets removed, and costs to Marin County, California, during previous and current predator management programs.

Fiscal Year	Adult Sheep Killed	# Head, Lost / Paid	Lambs Killed	Total Head Killed	Coyotes Taken	Non-targets Taken	Cost to County
1995-96*	22		117	139 [a]	27 [a]	0 [a]	$12,420
1996-97*	34		77	111 [a]	32 [a]	7 [a]	$13,518
1997-98*	45		141	186 [a]	21 [a]	7 [a]	$13,128
1998-99*	90		243	333 [a]	17 [a]	5 [a]	$38,526
1999-00*	43		137	180 [a]	14 [a]	0 [a]	$28,560
2000-01**	44 [a]		614 [b]	658	2 [a]	0 [a]	0
2001-02**	97 [c]	97 [c]		?	~40 [d]		$36,536 [e]
2002-03**	236 [c]	236 [c]		?	~50 [d]		$50,354 [e]
2003-04**	158 [c]	158 [c]		?	~50 [d]		$37,778 [e]
2004-05**	149 [c]	149 [c]		?	~70 [d]		$33,960 [e]
2005-06**	165 [c]	165/89 [c]		?	~100 [d]		$32,311 [e]
2006-2007**		204/139 [c]					$29,223
2007-2008**		247/181 [c]					$39,631
2008-2009**		163/148 [c]					$37,225
2009-2010**		93/0 [c]					$22,725
2010-2011**		135 [c]					$14,300
2011-2012**		29 [c]					$5,400
2012-2013**		0 [c]					$19,338
2013-2014**		0 [c]					$20,252
2014-2015**		0 [c]					$17,850
Data from current survey:							
2000-2005 [f]	85		454	539	~201		
2005-2010 [e]	67		558	625	~231		
2010-2015 [e]	62		366	428	~301		

* Federal Fiscal Year Oct. 1 - Sept. 30
** County Fiscal Year Jul. 1 - Jun. 30
[a] documented plus reported to WS
[b] reported to WS, not documented
[c] reported by ranchers to County
[d] estimated, Larson (2006)
[e] pers. comm., Marin Co. Ag. Commissioner's Office
[f] current survey results

(2 of 13, or 15%). The advantage for these ranchers is that they can obtain cost-share subsidies (maximum of $3,000 annually) for performing non-lethal predator management improvements. Disadvantages of the LPP are that sheep producers who lease, rather than own, their pastures or rangelands usually do not wish to incur the cost of fence improvements, even if cost-shared; some who are already using night confinement, shed lambing, and other such non-lethal techniques are not eligible to be compensated for "adding" methods already in place; and use of scare devices is generally of little effectiveness.

Sheep and Lamb Losses

During the first year of the LPP (Fiscal Year 2001-02), there were 97 total sheep and lamb losses reported. The next 5 years' data indicate that losses increased above those reported in 2001-02 (Table 1). Based on data submitted by the 13 to 18 ranchers who reported losses to the county from FY2001-2002 through FY2005-2006, and using the county-established method of calculating percentage loss that determines when the payment cap is reached (total sheep and lambs lost to predators, divided by the total number of adult sheep), individual producers suffered predation losses ranging from 0% to 18.6%. During the first 5 years of the LPP, sheep and lamb losses as a percentage of the adult flock ranged annually from 2.21% to 4.15%. However, between 2 and 6 producers in any given year reported sheep and lamb losses ≥5%, while between 4 and 9 producers reported 0% predator losses. In FY2002-2003 one producer with 307 head of adult sheep reported predation losses of 57 sheep and lambs (Larson 2006). Such variability in loss experience is typical in sheep operations and can be attributed to wide number of factors, such as location, management methods, predator control strategies employed, and the propensity of individual coyotes to kill livestock.

There is no way to confirm whether sheep and lamb losses reported following the cessation of the Wildlife Services program (beginning in FY2000-2001) are representative of actual losses county-wide. Initiation of the compensation program may have provided more incentive for producers to report losses during the first 5 years of the LPP, while producers who chose not to participate in the LPP did not report their losses. Further, O'Gara (1982) noted that while some ranchers undoubtedly report higher predation losses than actual, others report fewer than actual because carcasses and other evidence of predation are often difficult to locate.

It is common knowledge that lambs, particularly small lambs, are more vulnerable to coyote predation than are adult sheep. The reported total of 614 lambs killed during FY2000-2001 seems large in comparison to reports of other years. Data on lamb losses from past studies indicate that lamb losses can be 4 to 10 times those of adult sheep losses to coyotes (DeLorenzo and Howard 1977, Gee et al. 1977, McAdoo and Klebenow 1978). Public discussions about terminating Marin County's program with Wildlife Services during the year preceding initiation of the LPP may have stimulated producers to be more diligent with reporting of losses.

Field research also provides evidence that cessation of lethal removal of coyotes from rangelands can result in significant increases in predation losses. O'Gara et al. (1983) found that when lethal predator control was discontinued on a western Montana sheep ranch, predators (primarily coyotes) killed approximately 27% of available lambs during spring and summer over a 2-year period. At the University of California's Hopland Research and Extension Center, confirmed coyote predation on lambs increased from 59 verified kills during the period 1990-1992, while lethal coyote control was being conducted in response to predation, to 181 verified kills during the period 1994-1996, when lethal control was not done due to coyote behavioral studies. However, greater labor was invested in searching for dead lambs was made during the latter period. Thus, a more representative measure may be the total of verified coyote kills plus total lambs found to be missing during these two periods: 339 lambs during 1990-1992, vs. 664 lambs during 1994-1996 (unpubl. data, UC Hopland R & E Center). Inasmuch as increased human activity is known in some cases to reduce coyote predation, the effect of ceasing lethal coyote control likely falls somewhere between these two measures.

Satisfaction with Cost-Share and Compensation

Respondents were asked to rate their satisfaction with the amount of cost-share ("financial assistance") received through the LPP. In our analysis, responses to this question on the survey were weakly negative; however, since they were not significantly different from "zero", we interpret them as ambivalent (Figure 5).

Respondents were asked to rate their satisfaction with the amount of compensation for predation losses received through the LPP. Again, in our analysis, responses to this question on the survey were weakly negative, and since there were not significantly different from "zero", we interpret them as ambivalent (Figure 5).

In our interviews, producers discussed the lack of funding for the compensation of losses due to predation. In the first year of the LPP, producers received full compensation for all losses incurred. There was an increase in total compensation payments in the second year of the LPP, indicating a greater depredation occurrence just one year after the removal of Wildlife Services (Figure 4). Even after the 5% loss cap was implemented, the amount paid for compensation remained high until this component was eliminated in 2009. Some producers felt the amount of compensation received, especially after the loss cap was instituted, was inadequate. Changes in total compensation paid after

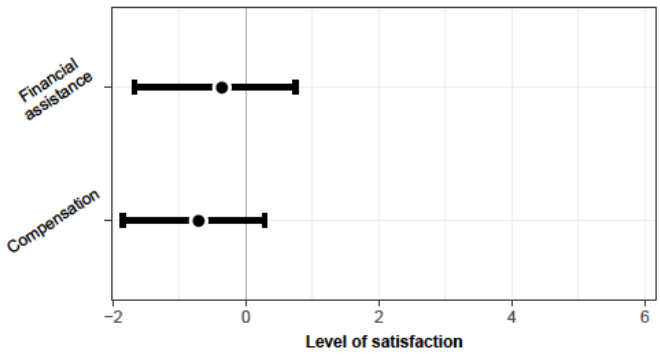

Figure 5. Level of satisfaction with Financial Assistance and Compensation among producers participating in the Marin County Livestock Protection Program. Positive numbers indicate satisfaction, while negative numbers indicate dissatisfaction; 95% confidence intervals overlapping zero indicate pooled data not significantly different from "no opinion".

FY2004-05 were in part a result of fewer producers participating in the compensation program. Once the compensation component of the program was eliminated, most producers ceased reporting their losses.

The total of participating sheep producers with ≥200 head steadily decreased during the past decade, even though these producers are still listed as participants in the program (email comm., Stacy Carlsen, Marin County Ag Commissioner). However, we have no reliable source of data for total sheep numbers in the county in recent years; we believe the Agricultural Commissioner's annual Crop Reports have used estimates of sheep numbers in the past decade, rather than actual census data. Smaller flocks might lead to an easier job of making non-lethal tools effective, so if documented total losses continued to increase, this would be evidence of the non-lethal approach not being effective in dealing with a growing predation problem.

Management Changes

Producers were asked whether, since participating in the LPP, their efforts in managing predator losses had increased or decreased. The question focused on specifying labor, expenses, and management techniques. Raw results indicated that overall, producers reported that expenses increased substantially, and labor as well as management efforts increased. Our analysis of the data in response to this question is show in Figure 6.

The majority of active sheep producers responding stated they wouldn't still be in business if it weren't for their guard dogs, and several also felt that improved fencing was their best tool to reduce predation losses. Fox (2008) stated that the LPP has helped to reduce livestock losses and has resulted in an increase in the use of non-lethal predation deterrent methods by a majority of participating ranchers; our survey concurred with the increased usage of guard dogs. However, the LPP cost-share does not adequately cover the costs of dog acquisition, feeding, veterinary services, etc.

There is also the potential for guard dogs to have negative effects on desirable or beneficial wildlife. Van Bommel and Johnson (2016) stated that harassment of wildlife by livestock guarding dogs is evidently common. Redden et al. (2015) noted that guard dogs may harass or kill deer, small game, and game birds (especially ground-nesting species). If their harassment of potential coyote prey results in local reductions in prey populations, this may result in coyotes relying more heavily on livestock. Timm and Schmidt (1990) noted that guard dogs at the Hopland R & E Center appeared to harass wild turkeys, and they reported observing guarding dogs regularly killing deer fawns.

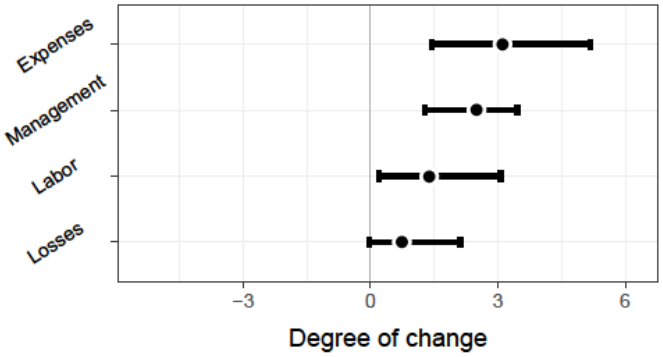

Figure 6. Responses of survey participants in regard to managing sheep and lamb predation under the County's Livestock Protection Program, FY2001-2015 (after the end of the USDA Wildlife Services program in Marin County). Positive numbers indicate an increase, while negative numbers indicate a decrease. Pooled data indicate ranchers' expenses, management inputs, and labor all significantly increased. Ranchers' responses also indicated an overall increase in predation losses, however overlap of the 95% confidence interval with zero indicates absence of statistical significance.

Predation Control Method Satisfaction

On our survey, we asked respondents to rank their level of satisfaction in regard to various predation control methods. We infer that respondents who expressed an option (as opposed to marking "no opinion") had employed or attempted to employ the particular method.

Use of shooting, employing livestock guard dogs, and use of snares were the methods deemed most effective by producers who responded. It should be noted that while snares were considered a useful tool, if guard dogs are used, snares present a risk to the dogs. General satisfaction was also expressed with use of protective pasture corrals, "other" (i.e., non-electric) fencing, and to a somewhat lesser degree, electric fencing.

From our survey responses, it appears that use of llamas and of lambing sheds were satisfactory for some producers but unsatisfactory to others. In discussions with producers, they often reported that guarding animals (dogs and llamas) worked well only in smaller pastures (<50 acres). No producers provided opinions about "increased lighting", which we interpret to mean that they did not employ the method, or if they did, they were ambivalent about its effect on predation. Regarding scare devices (i.e.,-radios, flashing lights, alarms, scarecrows, etc.), producers either had "no opinion" or checked the responses "somewhat dissatisfied" or "highly dissatisfied" (Figure 7).

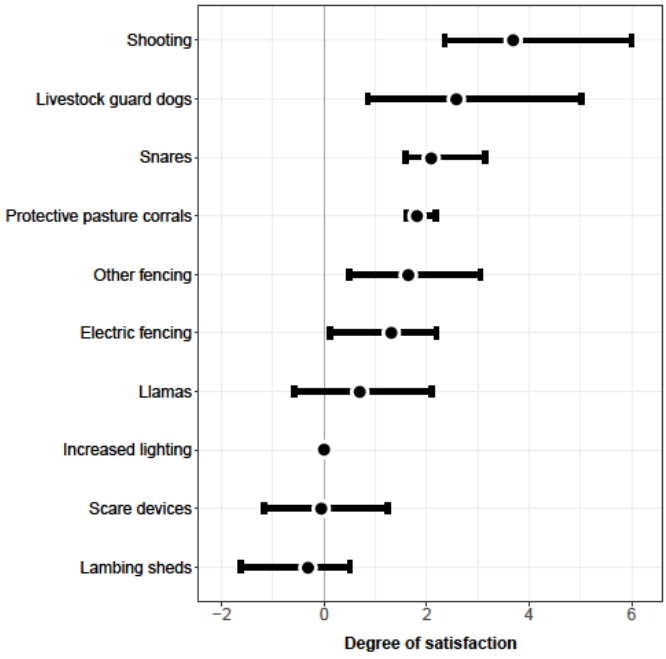

Figure 7. The level of satisfaction with predator control methods as reported by producers participating in the Marin County Livestock Protection Program. Positive numbers indicate satisfaction, while negative numbers indicate dissatisfaction. Where 95% confidence intervals overlap zero, we interpret these results to indicate that producers as a whole were ambivalent about the method.

Sheep and Lamb Losses to Predation

When asked if their losses of livestock to predation decreased, increased, or remained the same after the Wildlife Services Program was discontinued in Marin County, 7 of 11 producers reported losses had increased, 3 reported they remained the same, while 1 reported losses decreased. This contrasts with results reported in the previous survey conducted by Fox (2008:55), who stated that of 12 respondents, 3 reported increased livestock losses, 5 reported the same magnitude of loss, and 4 reported decreased losses. Our analysis showed that while our data indicated overall sheep and lamb losses generally increased, the overlap of the 95% confidence interval with zero indicates the increase was not significant (Figure 6).

Coyotes and Non-Target Animals Killed

Regarding the number of coyotes removed before and after the switch to the LPP, we believe data collected during the WS program is an accurate reflection of the coyotes removed by the WS specialist. Because WS's formal agreement with cooperating landowners specified that the

rancher must not attempt coyote control except as agreed by the specialist, it is unlikely that the total number of coyotes removed on cooperating ranchers' properties was significantly higher than reported (Larson 2006). There were coyotes taken by producers before 2000; however, the number is much less than after 2000, because producers lacked skill level and time. However, it is not known how many coyotes were removed by landowners on properties that were not visited by the WS specialist, since individual ranchers were allowed to kill coyotes by any legal method (i.e., shooting, snaring, or killing pups in dens). Documentation of coyotes taken by Wildlife Services ceased when the WS program ended in 2000; and data on coyotes taken after 1999 represents an estimate based on ranchers' personal knowledge and opinions. We believe that WS specialists were more selective in removing only offending coyotes than are most landowners (Larson 2006).

Livestock producers and other landowners are still allowed to lethally remove coyotes. All producers reported they have predator calls and rifles, and they or their agents still hunt and kill coyotes found on their properties; however, these animals many or may not be depredating their livestock. They acknowledged the difficult of individual ranchers trying to effectively target and remove livestock-killing coyotes, as not all ranchers have the aptitude or training to become efficient at predator control.

Producers were asked to estimate the numbers of coyotes that had been taken in Marin County since the implementation of the LPP. Individual producers and others working on their behalf routinely practiced snaring, calling and shooting, and denning in an effort to reduce coyote predation. Coyote removal is perhaps most intense in winter and spring, in response to increased incidence of predation, primarily loss of lambs. On occasion, ranchers reported working together to form hunting parties in an effort to eliminate depredating coyotes, particularly when adjacent ranches suffered episodes of repeated losses over a period of several days.

Within the first 5 years of the LPP's initiation, some ranchers relied on the predator control expertise of one of their fellow program members, who during that time hunted, called in, and subsequently shot coyotes on fellow ranchers' properties at their request. This individual reported taking approximately 40-50 problem coyotes annually (Larson 2006). It is likely that some ranchers themselves are taking more coyotes than when the WS program was in place, as WS specialists requested that cooperating landowners not attempt coyote control efforts themselves except by agreed-upon methods, in order to reduce the chance of coyotes becoming wise to snares, traps, or other devices that landowners might use with less expertise than the WS specialist (Larson 2006).

In our survey, producers were asked to estimate the number of coyotes lethally removed, either by themselves or their agents working on their properties, over three 5-year periods since cessation of the USDA Wildlife Services Program. Total estimated coyote kills from survey results are shown in Table 1 and indicate a trend of increased number of coyotes taken; these estimates suggest a 50% increase in coyote removal during the most recent 5-year period, as compared to the first 5 years of the LPP, during what we believe is a reduction in sheep numbers and acreage grazed within Marin County.

Fox (2008) stated that because of variability in data collection, monitoring, and reporting, it is difficult to accurately assess differences in the numbers of predators killed under both programs. However, as previously suggested by Larson (2006), it appears that lethal removal of coyotes has increased under the LPP as compared to when the USDA Wildlife Services program was operating (see Table 1). In addition, there are no data on the number of non-target species taken after 2000. However, successful use of snares, which remained one of the few legal capture tools following the passage of California's Proposition 4 in late 1998, requires considerable expertise in order to avoid capturing non-target species (Huot and Bergman 2007, Proulx et al. 2015).

Producer Satisfaction with the Livestock Protection Program

Three producers stated that it became harder for producers in brushy areas, or those who couldn't meet the LPP requirements, to stay in business, and they ceased sheep production. This placed more pressure on remaining producers, who were no longer "buffered" by neighboring sheep ranches.

Fox (2008) concluded, from survey data obtain in 2006, that the LPP ("Marin Program") had support from a majority of participating ranchers. Fox (2008) also stated the LPP is preferred over the USDA Wildlife Service's traditional predator management program by the majority of participating ranchers. Our data indicate, however, that since 2008, six producers went out of business, likely placing more predation pressure on those that remained in business. One producer stated that after 84 years of his family's raising sheep on the property, he was selling and getting out of the sheep business due to increased coyote depredation. He likened the current program to "giving a Band-Aid to someone with a severed artery."

Our survey allowed producers to provide comments: 8 of 11 producers commented that there were insufficient funds to run the program. Several producers wanted the compensation program reinstated, and for it to pay for all losses without a cap. Two producers suggested that funding be made available to hire a USDA Wildlife Service specialist during lambing season. Three producers, all involved in the program creation, expressed dissatisfaction with the current program direction; they noted that it was developed to address both environmentalists' and ranchers' wishes/needs, but it has not evolved to address the impacts of increasing coyote depredation.

EVALUATING THE WS vs THE LPP PROGRAM

Ideally, an evaluation of the Marin County Livestock Protection Program would involve comparing data from that program to data from the last 5 years of the WS program (October 1995 - September 2000). However, the means used to collected data on sheep and lamb losses and the number of coyotes removed is inconsistent between the two periods. The WS specialist did not report losses occurring on ranches with which he had no working agreements; it is estimated that his reports of livestock loss represent approximately 2/3 of all viable sheep ranchers in

Marin County during that period. During the last few years of the WS program, WS had formal working agreements with between 25 and 45 ranchers covering up to 73,000 acres of land (Carlsen 1999). In contrast, data reported by the Agricultural Commission's office reveals that LPP participants' total acreage has not exceeded 14,500 acres in any of the past 5 years since FY2009-2010. Further, the number of available sheep and lambs, as well as their distribution on the landscape, has changed through time; these variables may affect predator losses in unpredictable ways (Larson 2006).

The difficulty in making a comparison between the former WS program and the current county-run LPP is not unexpected. The Marin County Agricultural Commissioner noted, during discussion of the potential change in programs, "Privatizing predator control would eliminate the ability to…maintain public records of control activities, [and] would make reporting of livestock and wildlife losses and damage, speculative at best" (Carlsen 2000). We also note that various organizations promoting the current Marin County LPP as a model for other geographic areas tout this program as a non-lethal alternative to the Wildlife Services approach (Anonymous 2015, Project Coyote *n.d.*, Little Blue Society 2016). In our opinion, this ignores the reality that Marin County landowners and their agents continue to implement lethal control, likely are killing more coyotes than were taken previously, and predator removal may now be practiced in in a less selective manner than when it was done by WS professionals.

Further, Shwiff et al. (2006:359) stated that "The Wildlife Services program achieves certain economies of scale that individual replacement programs do not. This is a result of efficiency gains inherent in WS operations due to the fact that WS can use a broad spectrum of available resources and technology to mitigate wildlife damage problems … The current economic analysis of WS activities in CA demonstrated that multiple returns on invested cooperative dollars were provided to the cooperating counties. Wildlife damage protection was afforded mainly for agriculture, but protection of health and human safety, natural resources, and property were also key areas."

CONCLUSION

With fewer than 20 sheep ranchers participating, Marin County has provided a program that included both a cost-share and a compensation component, which was capped at 5% total losses (FY2005-06), not funded (FY2009-10), paid in FY2011-12, but completed eliminated (FY2012-13 through FY2014-15). Replicating this exact program in other jurisdictions may not be financially feasible (i.e., in a county with hundreds of livestock producers); even Marin County was unable to fully compensate livestock lost to predators for more than a few years, and then found it necessary to abandon the compensation component of its program.

Given the circumstances, perhaps the Marin County Livestock Protection Program was the only sort of compromise that could be reached by a publicly-elected Board of Supervisors in an affluent area, where most voters are urbanites who have values typical of urban populations. In such environments where most people have little understanding of agriculture or principles of wildlife management, many people equate the selective removal of problem predators with inhumane treatment of animals, or fear that government agencies are, at the behest of powerful economic and political forces, causing grave harm to ecosystems in the absence of any such evidence.

The current program was implemented only after contentious debate within Marin County, accompanied by intense lobbying, particularly by animal welfare proponents and their organizations. While the current LPP is described (by activists) as "…a current model that has successfully addressed and embraced ethical concerns as well as differing values expressed by both the animal protection and ranching communities (Fox 2001, Fox and Papouchis 2005 cited in Hadidian et al. 2006), this opinion is not necessarily shared by the livestock production community, either in Marin County or elsewhere within California. It may, in fact, be difficult to transfer this program to other areas, based on geographical and demographic differences (pers. comm., S. K. Carlsen, Marin Co. Agricultural Commissioner, 2006). These same animal welfare proponents and their organizations have even stated, "Marin County may work for Marin County; however, this model may not be directly applicable or feasible in all other communities" (Fox 2008:74).

The results from the present survey, coupled with our knowledge of the ranching and wildlife communities in Marin County, we conclude that the Livestock Protection Program has led to changes that are detrimental both to ranchers and to the wildlife of Marin County.

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Marin County Livestock Protection & Compensation Programs
Rancher Survey - 2015

1. What livestock do you raise and how many of each did you own as of December 31, 2015? (Check all that apply)

_____ Sheep (# of adult head _____: # lambs _____)
_____ Beef cows (# of adult head _____: # calves _____)
_____ Dairy cows (# of adult head _____: # calves _____)
_____ Poultry
_____ Other (list species _____ and
# of adult head _____: # young _____)

2. Please indicate the **ESTIMATED TOTAL** number of head of livestock you've raised (to final stage) during the following time periods:

2000-2005 sheep _____ lambs _____ cows _____ calves _____ poultry _____
Other _____

2006-2010 sheep _____ lambs _____ cows _____ calves _____ poultry _____
Other _____

2011-2015 sheep _____ lambs _____ cows _____ calves _____ poultry _____
Other _____

3. What were the three most common causes of livestock mortality (e.g., weather, predation, disease, birth complications, etc.) for your operation during the following time periods: one (1) being most common?

	2000-2005	2006-2010	2011-2015
1.	_____	1. _____	1. _____
2.	_____	2. _____	2. _____
3.	_____	3. _____	3. _____

4. Please indicate the **ESTIMATED TOTAL** number of sheep, lambs, cow, calves, poultry, or other livestock you have lost due to predation during the following time periods:

2000-2005 sheep _____ lambs _____ cows _____ calves _____ poultry _____
Other _____

2006-2010 sheep _____ lambs _____ cows _____ calves _____ poultry _____
Other _____

2011-2015 sheep _____ lambs _____ cows _____ calves _____ poultry _____
Other _____

5. Please list the top 3 predator(s) that cause livestock losses or agricultural damage on your property (e.g. badgers, bobcats, coyotes, foxes, free roaming dogs, golden eagles, mountain lions, ravens, etc.) **in order of most to least problematic species:**

_____
_____
_____

6. Did you receive predator control services through the USDA Wildlife Services program prior to Marin County's adoption of the cost-share program?

_____ Yes _____ No

7. Please list the **ESTIMATED TOTAL** number of predators that were lethally removed by Wildlife Services to protect your livestock **during the following time periods:**

1990-1995 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Other (please specify species and total removed) _____

1996-2000 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Other (please specify species and total removed) _____

2001-2005 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Other (please specify species and total removed) _____

2006-2010 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Other (please specify species and total removed) _____

2010- 2015 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Other (please specify species and total removed) _____

8. If you had experience with the USDA Wildlife Services livestock protection program, what do you believe are its strengths and weaknesses?

_____
_____

9. What predator defense techniques did **you** use on your ranching operation **PRIOR to the implementation of the Marin County Livestock Protection program (before 2000)? (Please check all that apply and please note that all methods listed below are legal under California law).**

___ Livestock guard dogs
___ Livestock guard llamas
___ Electric fencing Protective pasture corrals
___ Other improved fencing (i.e. patch, cross, etc.)
___ Scare devices (i.e. radios, flashing lights, alarms, scarecrows)
___ Other, please specify: _____

___ Increased lighting
___Lambing shed
___ Snares
___ Shooting
___ None

10. Upon the removal of USDA Wildlife Services in 1999, did you participate in the **Marin County Livestock Protection** program and receive financial assistance for implementing predation deterrent techniques (fencing, guarding animals, scare devices, husbandry practices)?

_____ No, (if not, please state why you did not participate):
_____
_____

_____ Yes (if yes, please check each fiscal year (starting July 1) that you participated)

2000 __	2004 __	2008 __	2012 __
2001 __	2005 __	2009 __	2013 __
2002 __	2006 __	2010 __	2014 __
2003 __	2007 __	2011 __	2015 __

11. Through the Marin Co. **Livestock Protection Program (2000 forward),** which predation deterrent techniques did you use and receive financial assistance from the county? (Please check all that apply)

_____ Guard dogs
_____ Which breed of dog(s)
_____ Guard llamas
_____ Guard animal maintenance (food and vet bills)
_____ Electric fencing
_____ Other improved fencing (i.e. patch, cross, etc.)
_____ Scare devices (i.e. radios, flashing lights, alarms, scarecrows)

_____ Increased lighting
_____Lambing shed
_____ Protective pasture corrals
_____ Other, please specify: _____

12. Since participating in the Marin County Livestock Protection program, have your efforts in managing predator losses increased or decreased:

Labor: _____ Increased greatly _____ Decreased moderately
_____ Increased moderately _____Decreased greatly
_____ Remained the same

Expenses incurred: _____ Increased greatly _____ Decreased moderately
_____ Increased moderately _____Decreased greatly
_____ Remained the same
What Expenses:_____

Management Techniques used: _____ Increased greatly _____ Decreased moderately
_____ Increased moderately _____Decreased greatly
_____ Remained the same
What Management Techniques: _____

13. Did your losses of livestock to predators decrease, increase, or remain the same after the Wildlife Services Program was discontinued in Marin County?
_____ Decreased _____ Increased _____ Remain the same

14. Did you personally, or did you hire someone (alone, or in cooperation with other producers) to remove predators? If so, estimate how many predators were taken and which species.

2000-2005 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Any non-targeted ones (please specify species and total removed) _____

2006-2010 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Any non-targeted ones (please specify species and total removed) _____

2011-2015 hogs ___bobcats _____ coyotes _____ foxes _____ mountain lions ____
Any non-targeted ones (please specify species and total removed) _____

15. Please indicate your level of satisfaction with each method with an X in the appropriate category (please check all that apply and please note that all methods are legal under California law):

Method	Highly satisfied	Somewhat satisfied	No opinion	Somewhat dissatisfied	Highly Dissatisfied
Livestock guard dogs					
Llamas					
Electric fencing					
Other fencing					
Scare devices*					
Increased lighting					
Lambing sheds					
Protective pasture corrals					
Snares					
Shooting					

*Scare devices = radios, flashing lights, alarms, scarecrows, etc.)

16. **Looking back on all of your experiences,** what is your preferred method of preventing predation on livestock? _____

_____

17. Are you able to use your preferred method(s) currently?
_____ Yes _____ No (if no, why not? _____

_____

18. Please indicate your level of satisfaction with the amount of financial assistance you received through the **Marin Co. Livestock Protection Program**?
_____Highly satisfied _____Somewhat dissatisfied
_____Somewhat satisfied _____ Highly dissatisfied
_____No opinion
Please explain your answer in the space provided: _____
_____
_____

In this section, questions pertain to the Marin County COMPENSATION PROGRAM (payment for losses), which started in 2000 and ended approximately 2007.

19. Did you receive **compensation for livestock** that were killed by coyotes or other predators through the Main indemnification/compensation program?
_____ No _____ Yes (if yes, please check each year that you participated):

_____ 2000 _____ 2004
_____ 2001 _____2005
_____2002 _____ 2006
_____2003 _____2007

20. Please indicate your level of satisfaction with the amount of compensation **you've received overall and how does that pay for your expenses?**
_____Highly satisfied _____Somewhat dissatisfied
_____Somewhat satisfied _____Highly dissatisfied
_____No opinion
Please explain your answer in the space provided: _____
_____
_____

21. Please express any additional comments you'd like to provide about **Marin County's Livestock Protection Program and/or Compensation Program** (feel free to provide additional comments on the back):
_____
_____
_____

If you would like to speak with me as a follow up to this survey, please provide your phone number and email address below and a convenient time to reach you. Phone: _____ Email: _____
Preferred method of contact and best time to reach you:

_____

Thank you for participating in this survey. We greatly appreciate your help in evaluating this program.