Paying for Prevention: Evaluating Arizona Rancher Spending to Avoid or Reduce Livestock Conflicts with the Mexican Gray Wolf

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ABSTRACT: The reintroduction of the Mexican gray wolf to the southwest U.S. has been controversial because of documented wolf-livestock conflict (and fear of potential conflicts). Wolf-livestock interactions can lead to economic losses for ranchers directly from depredation and indirectly through physiological impacts on livestock such as weight loss. Ranchers report that, in addition to economic losses, they face additional management costs due to the presence of wolves. Relying on a survey of Arizona ranchers, this study explores ranchers' attitudes toward wolf reintroduction, identifies and estimates the costs of management practices implemented by ranchers to avoid or reduce wolf-livestock conflicts, and examines how spending on preventative management practices, including the value of ranchers' time, compares with net returns per cow under three different price scenarios: a low-price, mid-price, and high-price year. Building upon literature that finds ranchers are motivated by lifestyle and other non-monetary benefits of ranching, we posit that factors beyond profit maximization influence ranchers' decision to implement management practices to limit wolf-livestock conflicts. We find that spending on preventive management practices can be large relative to net returns. We also find that negative attitudes toward wolves are not well correlated with experiences with or losses from wolf depredation. These results illuminate the complexity of rancher attitudes and management decisions, with implications for predator coexistence and conservation efforts.

KEY WORDS: *Canis lupus baileyi*, depredation, economic damage, livestock, Mexican gray wolf, preventative management practices, tolerance, wolf-livestock conflict

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INTRODUCTION

Wildlife conflicts with livestock have long presented a challenge for protection of threatened and endangered species, particularly for apex predators (Mech 1995, Naughton-Treves et al. 2003). While public support for species conservation is often high, the costs of conservation and predator reintroduction are most heavily borne by those that live or derive their livelihoods in or around the species' habitats (Mech 1995, Naughton-Treves et al. 2003), giving rise to conflict. Reintroduction of the Mexican gray wolf in Arizona and New Mexico has been highly contentious. The Mexican gray wolf (*Canis lupus baileyi*), endemic to the southwest United States and northern Mexico, was listed as endangered in 1976 after years of extirpation efforts and population decline (USFWS 2014). Following that designation, the Mexican Gray Wolf Recovery Program was developed to reintroduce a "nonessential experimental" population in the wolf's historic range (USFWS 2014). In 1998, Mexican wolves were reintroduced into the wild in an area known as the Blue Range Wolf Recovery Area (BRWRA), wholly located within the Apache and Gila National Forests in east-central Arizona and west-central New Mexico.

Cattle ranching is prevalent in and around the BRWRA and wolf presence has resulted in documented incidents of wolf-livestock conflict, including depredation. Ranchers express concern over direct and indirect losses due to wolf presence, and the implications of continued financial losses for their way of life. Ranchers report that, in addition to economic losses, they face additional management costs due to wolves. Despite compensation programs that help offset losses, resistance to reintroduction remains high among ranchers.

Ranchers operate to maximize profits and compensation programs that fully cover the costs and losses resulting from wolf presence should generate a greater level of tolerance towards wolf reintroduction. Similarly, ranchers should adopt management practices and invest no more than they would expect to gain from the sale livestock. Previous research has found, however, that ranchers have diverse motivations for ranching, profit maximization only one among many (Tanaka et al. 2005). Numerous studies have demonstrated that ranchers place a high value on the ranching/rural lifestyle, with ranching not only providing productive value but also consumptive value (Martin and Jeffries 1966, Smith and Martin 1972, Torell et al. 2001). Furthermore, research suggests that tolerance of wildlife is influenced by factors including social identity and perception of risk (Williams et al. 2002, Naughton-Treves et al. 2003, Dickman 2010). Compensation for losses, therefore, may be insufficient to increase tolerance of wolf presence and rancher management decisions may not be optimal from a profit maximization standpoint. Expectations of losses can be influenced by individual and circumstantial factors, and motivations may extend beyond profit maximization, leading to preventative practices that may not be profit-maximizing. To explore this, we examine rancher investment in preventative management practices to avoid or reduce livestock depredations by wolves, as well as rancher attitudes towards conservation and reintroduction, relying on a survey of Arizona ranchers in and around the BRWRA.

BACKGROUND

Mexican gray wolves were reintroduced in 1998 in the BRWRA in eastern Arizona and western New Mexico

(USFWS 2014) where cattle ranching is prevalent. A concern for ranchers is the direct financial losses sustained due to wolf depredation. Numerous studies have examined the depredation impacts of wolves (Oakleaf et al. 2003, Muhly and Musiani 2009, Sommers et al. 2010, Breck et al. 2011). Generally, calves are more commonly killed by wolf attacks than cows, bulls, or yearlings (Oakleaf et al. 2003, Sommers et al. 2010, Breck et al. 2011), though there has been confirmed depredation of cows and, in rare cases, bulls (Defenders of Wildlife 2010). Previous studies have estimated wolf depredation rates on the order of 1.2% to 1.9% on individual ranch allotments (Oakleaf et al. 2003, Sommers et al. 2010). However, effects on individual operations can be quite significant as impacts can be unevenly spatially distributed. For example, a study in Alberta, Canada found depredation losses from all carnivores ranging from 0% to 25% for individual producers, with 2.6% of producers experiencing calf depredation losses greater than 10% per year (Lee et al. 2016).

Estimating the exact number of cattle depredated by wolves is difficult. Locating carcasses is challenging and detection of mortalities due to wolves is low (Oakleaf et al. 2003, Sommers et al. 2010, Breck et al. 2011). In 2016, the USFWS reported 56 incidents as confirmed or probable Mexican gray wolf depredations or injuries (USFWS Service 2016). However, given the rugged and remote terrain of the BRWRA, it can be difficult or impossible to locate all depredated cattle. Of those cattle found, determining cause of death can be difficult due to prolonged exposure to the elements, decomposition, and damage by other predators or scavengers. This can result in unconfirmed depredation incidents and uncompensated losses.

Another concern for ranchers is the indirect and physiological impacts that wolf presence has on their herds. Lehmkuhler et al. (2007) state, "the regular presence of wolves in close proximity to livestock may result in a chronic stress situation for the domestic animals" (p. 6). This can affect weight gain, conception rates, grazing patterns, and overall livestock behavior (Howery and DiLiberto 2004, Lehmkuhler 2007, Cooke 2013, Ramler et al. 2014, Clark et al. 2017). Whereas direct depredation incidents result in the loss of one or more animals, physiological impacts can occur across the herd, potentially resulting in larger financial losses (Rashford et al. 2010). Ramler et al. (2014) found the effects of wolves on calf weaning weights have the largest negative effect on ranch profitability (27%), followed by reduced conception rates and death loss (20%).

Compensation programs have been paying out claims since 1998 to offset losses experienced by ranchers from Mexican gray wolves (Defenders of Wildlife 2010). Initially, most programs focused on losses from depredation, though more recently, funds have become available to compensate ranchers for proactive and preventative measures, and for preemptive payment-for-presence. While compensation programs can offset losses, some question if they effectively compensate ranchers and whether they lead to increased tolerance and acceptance (Naughton-Treves et al. 2003, Treves at al. 2009, Nyhus 2016).

There is evidence to suggest that compensation programs don't necessarily result in social acceptance. Vynne (2009) found dissatisfaction among ranchers with the compensation process. Respondents expressed distrust of programs and organizations running them. Naughton-Treves et al. (2003) found the most important factor determining tolerance of wolves was social identity and occupation, more so than whether ranchers had lost livestock to predators. Attitudes towards wolves may be well-established even before a depredation occurs, and despite compensation received.

From a profit-maximizing standpoint, if compensation programs fully cover costs and losses from wolf presence, they should generate greater levels of tolerance towards wolf reintroduction among livestock producers (Dickman 2010). Similarly, were the conflict around reintroduction purely driven by ranch financial losses, management practices in response to wolf presence would behave consistent with profit maximization. Researchers, however, have found that social factors also drive conflict, and ranchers derive not only productive value from their ranch, but also consumptive value (Tanaka et al. 2005). Attitudes, perceptions of risk, and social factors influence individual tolerance of wildlife interaction and corresponding management decisions (Dickman 2010).

Rancher attitudes toward wolves influences whether programs addressing depredation losses are effective in achieving greater acceptance of wolf presence. Individual perception of risk can vary depending upon where a threat generates from. Seminal research by Starr (1969) found that individuals are more likely to accept risks they choose for themselves versus risks imposed on them externally. Mexican gray wolves were no longer a threat to livestock in the study area due to their extirpation, however, reintroduction by the federal government represents a new risk imposed on ranchers from the outside. Furthermore, rancher viewpoints towards conservation and government are complex. Some distrust towards the government and its policies is common, including the study area (Lien et al. 2017). This can exacerbate resistance to reintroduction (Kreye et al. 2017).

Attitudes towards wolves are also conditioned on proximity and vulnerability to the risk they present. Williams et al. (2002) find attitudes tend to be more negative amongst groups with the greatest likelihood of having direct experience with wolves, such as ranchers and those living in their territory. Proximity to the area of wolf reintroduction had an impact on initial support for wolf reintroduction in Eastern Arizona. Prior to wolf reintroduction, research found that, near the reintroduction site, nearly 60% opposed reintroduction, whereas opposition at the state-level was less than 20% (Johnson 1990, Schoenecker and Shaw 1997). While only 6% of area respondents were in the ranching business, 65% were concerned about livestock losses from depredation (Schoenecker and Shaw 1997). Aside from proximity and vulnerability, a person may be more able to imagine or recall events that happen to them personally, or to people they care about, resulting in greater emotional salience and higher perceived risks (Wilkerson 1992, Dickman 2010).

Beyond risk perceptions, social factors can affect rancher attitudes towards wolf reintroduction, including

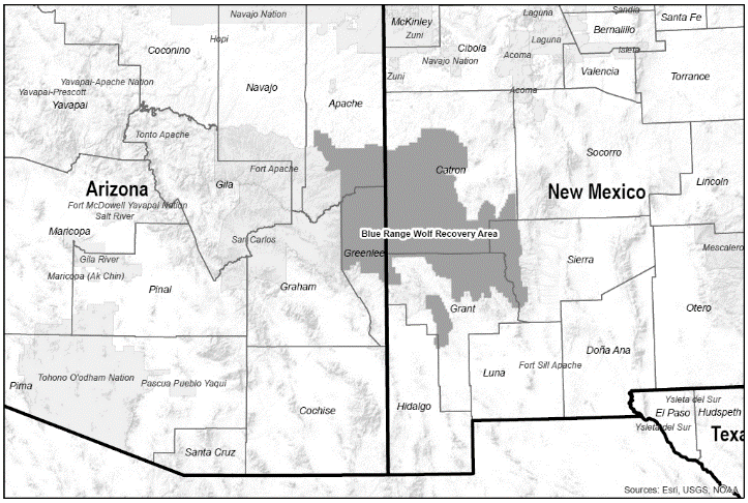

Figure 1. Blue Range Wolf Recovery Area and surrounding counties.

history and tradition, cultural norms, and other social conflicts. Globally, there is a long history of conflict between livestock producers and wolves (Fritts et al. 2003, Granlund 2018). Government-sponsored wolf eradication efforts led to the species' extirpation from broad ranges of the United States and Canada by the mid-20th century. In addition to reducing wolf population, these efforts perpetuated stories of massive depredation, influencing attitudes towards wolves (Fritts et al. 2003). Attitudes towards wolves also may align with other perceived social divides, such as the rural/urban divide. Williams et al. (2002) find negative attitudes towards wolves are associated with older age, living in a rural area, and being a rancher. Meanwhile, positive attitudes are associated with higher income, higher education, and living in an urban area. This echoes Naughton-Treves et al. (2003) who found the most important factor determining tolerance of wolves was social identity and occupation. Cultural identity and pre-existing social divides may exacerbate the conflict around wolf reintroduction, regardless of individual experience with or losses from wolves.

Considering the potential for economic losses from wolves, ranchers face the choice of whether to invest in management practices to avoid wolf-livestock interaction, and if so, how much to invest. Such practices include using range riders, moving or hauling cattle, additional herd monitoring, using fladry fencing or dogs to deter wolves, carcass removal, and diversionary food caches placement (Industrial Economics, Inc. 2005, Lehmkuhler 2007, Ramler, et al. 2014, USFWS 2016).

Ranchers' willingness to employ these practices depend on factors including their effectiveness, cost, feasibility (Amit and Jacobson 2017), and perception of control of the outcome (Wilkerson 1992). White (1961) and Wilkerson (1992) describe similar decision-making criteria for implementing preventative practices: 1) Will the practice reduce risk? 2) Is it economically efficient? 3) Is there access to expertise needed to implement it? and 4) Will the practice have spillover effects impacting other resource use?

Governed by these criteria alone, the decision-making process conforms to traditional notions of economic rationality (Wilkerson 1992). We posit, however, that ranchers' decision-making and underlying utility are dependent on a more nuanced set of considerations. Generally, use of preventative practices increases with predator density and past depredation incidents (Graham et al. 2005, Amit and Jacobson 2017). Nonetheless, Amit and Jacobson (2017) also found that social interactions and personal motivations affected decision making, factors that tended to be ignored by wildlife managers and researchers. These findings point to the importance of factors beyond traditional profit maximization in ranchers' decisions to address livestock depredations. As an extension, if profit maximization is not a rancher's only objective or decision-making criteria, compensation may not be sufficient to gain support for reintroduction efforts. This is bolstered by literature finding that ranch values are only partially reflective of productive potential, and heavily influenced by amenity and lifestyle values of the land (Martin and Jeffries 1966, Pope 1987, Torell et al. 2001, Torell et al. 2005).

This analysis relies on a survey of Arizona ranchers to examine rancher adoption of preventative management practices and attitudes towards reintroduction efforts. We compare spending on preventative practices to net returns on a per-cow basis and evaluate those against reported ranges of depredation experienced by ranchers. If some ranchers spend beyond what they expect to receive in returns, this would suggest that rancher utility may be dependent on factors beyond profit maximization. This has implications for compensation programs as a strategy to encourage cooperation with wildlife conservation efforts.

METHODS

A survey of Arizona cattle ranchers was conducted to collect information on ranch characteristics, interactions with wildlife (particularly Mexican gray wolves), management practices used to avoid or reduce wolf impacts, and experiences with and attitudes towards wolves. The survey was collected using snowball sampling techniques (Berg 1988) and targeted ranches in and around the BRWRA most affected by the presence of wolves. Of a total 28 respondents, 15 were not located within the

BRWRA (Figure 1), six were located fully in the BRWRA, and seven were partially within the BRWRA. Eleven of 28 respondents reported being impacted by wolves either directly through depredation or injury or indirectly through stress or other impacts. Conferring with ranching industry contacts in the region, survey responses appear to cover a high proportion of affected operations.

Analysis

Given that not all respondents were located in the BRWRA or had experienced wolf impacts, we expect some variation in attitudes towards wolves and wolf reintroduction, in part due to perception of risk. To explore this, we examine survey responses to attitudinal questions across the entire sample, then compare means across respondent segments. Segments are developed based on respondents' relative proximity to wolves, their past experience with wolves, their operation's vulnerability to depredation losses, and rancher attitude toward predators and their role in the environment.

Under the most basic profit-maximizing assumptions, we expect that respondents would not choose to invest in management practices beyond the point where expenditures exceed net returns on a per cow basis. To examine this, we compare respondent-reported spending on preventative management practices, including the value of ranchers' time, with net returns per cow. Individual ranch returns were estimated using respondent-reported calf sales and calf sale weights, three different calf price scenarios (a low-, mid-, and high-price year), and prevailing operating costs for the region during an average year (Teegerstrom and Tronstad 2017). Comparisons are made under no depredation and respondent-reported maximum depredation levels. Finally, the level of calf depredation that would have to occur for ranchers to "break even" on their reported preventative spending is estimated for a high-price year.

RESULTS

Attitudes Towards Wolves

Figure 2 presents the distribution of responses to attitudinal questions regarding reintroduction of Mexican wolves. Respondents rated their agreement using a 5-point Likert scale from 'strongly disagree' to 'strongly agree.' Most of the 28 respondents answered these attitudinal questions, whether or not they had experienced impacts from wolves.

Approximately 75% of respondents stated they agree or somewhat agree (hereon referred to as 'agree') that Mexican wolf depredation is a more serious problem than depredation by other predators, and 89% felt Mexican wolf presence is a threat to the ranching way of life (Figure 2). Regarding compensation, less than half (47%) of respondents agreed, and approximately one-fifth (21%) strongly disagreed with the statement "I would be more accepting of the presence of Mexican gray wolves if compensation covered its full costs." This supports findings from Naughton-Treves et al. (2003) who noted livestock producers, "who had been compensated for their losses to wolves were not more tolerant than their counterparts who alleged a loss but received no compensation." Nevertheless, it's important to understand the extent to which compensation ameliorates human-wildlife conflict. In response to the final statement "Compensation encourages cooperation between ranchers and wildlife conservation," aside from those that didn't respond, the most common response (29% of respondents) was neither agree nor disagree.

While we expect ranchers to share concerns regarding wolves, we also expect some variation in attitudes due to ranchers' perception of risk. To analyze these differences, we segment survey respondents four ways: 1) whether they are located in the BRWRA, 2) whether they've been affected by wolves in the past, 3) whether they derive 50% or more of their income from ranching, and 4) whether they agree with certain attitudinal questions regarding the environment. For the last category, we define a rancher as "eco-conscious" when they agree or strongly agree with all of the following statements, and not eco-conscious otherwise:

"The success of my ranching operation is tied to the health of the ecosystem."

"Predators are part of a healthy ecosystem."

"The presence of predators and other wildlife on public lands is a part of nature that comes with operating on these lands."

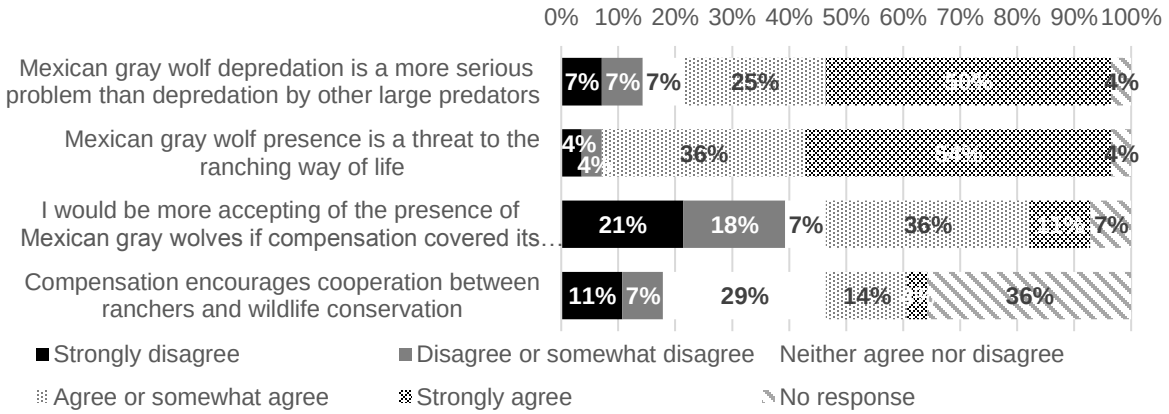

Figure 2. Arizona ranchers' attitudes about the Mexican gray wolf and compensation for wildlife-livestock conflict.

Agreement or disagreement is ranked on a five-point Likert scale and averaged across respondents, with means closer to 1 indicating that, on average, the group strongly disagrees with the statement, 3 indicating that the group neither agrees nor disagrees, and 5 indicating that the group strongly agrees with the statement. We evaluate the statistical significance of differences in means using the non-parametric Wilcoxon rank-sum test (Table 1).

Respondents not affected by wolves were more strongly in agreement that wolves are a more serious problem than other predators (statistically significant at the 90% level) and that they are a threat to the ranching way of life (significant at the 5% level), compared with affected ranchers. We also find unaffected respondents were more likely to disagree that they would be more accepting of Mexican gray wolves if compensation covered its full costs (significant at the 10% level), and more likely to disagree that compensation encourages cooperation between ranchers and wildlife conservation. In fact, of all unaffected ranchers, none strongly agreed with either of those statements. Interestingly, both ranchers located outside of the BRWRA and unaffected ranchers were more in agreement that wolf depredation is a more serious problem than depredation by other large predators and a threat to the ranching way of life, compared with their counterparts. Most respondents neither agreed nor disagreed that they would be more accepting of the presence of wolves if compensation covered its full costs, and that compensation encourages cooperation between ranchers and wildlife conservation. Yet, again, ranchers outside the BRWRA and those that hadn't been affected, tended to disagree with those statements more than those in close proximity and those that had experienced wolf depredation. These results are surprising as we would expect affected ranchers to have more negative attitudes toward wolves, but these results also lend credence to the idea that sources of conflict could be more complex. Income-vulnerable and less eco-conscious ranchers tended to have more negative attitudes toward wolves and appeared to be less accepting of wolves even if compensation were to cover its full costs. This group also tended to disagree that compensation encourages cooperation between ranchers and wildlife conservation, although the segment that is not income-vulnerable and eco-conscious generally felt neutral about the statement.

Calf Depredation

Respondents reported calf depredation levels ranging from 0% to 13% (Table 2). In a typical year, respondents reported an average calf depredation rate of 2%, ranging from 0% to 6%. Considering the year with the largest impacts, reported calf depredation rates ranged from 2% to 13%, with an average of 7%.

Table 2. Reported typical year and highest year calf death loss due to wolves.

	Typical Year Calf Death Loss	Highest Year Calf Death Loss
Minimum	0%	2%
Median	1%	6%
Average	2%	7%
Maximum	6%	13%
Mode	1%	N/A

Table 1. Arizona ranchers' attitudes about the Mexican gray wolf and compensation for wildlife-livestock conflict by segment.

	All Respondents (N = 28)	Located in BRWRA (N =13)	Not in BRWRA (N = 15)	Affected (N = 11)	Not Affected (N = 17)	Income-Vulnerable (N = 17)	Not Income-Vulnerable (N = 11)	Eco-Conscious (N = 11)	Non-Eco-Conscious (N = 17)
Mexican gray wolf depredation is a more serious problem than depredation by other large predators									
N =	27	13	14	11	16	17	10	11	16
Mean	4.07	3.69	4.43	3.82	4.25	4.12	4.00	3.73	4.31
T-Test***	N/A	0.15		0.11		0.89		0.16	
Mexican gray wolf presence is a threat to the ranching way of life									
N =	27	13	14	11	16	17	10	11	16
Mean	4.37	4.23	4.50	4.00	4.63	4.41	4.30	4.09	4.56
T-Test	N/A	0.38		0.02**		0.84		0.03**	
I would be more accepting of the presence of Mexican gray wolves if compensation covered its full costs									
N =	26	12	14	10	16	16	10	11	15
Mean	2.96	3.00	2.93	3.60	2.56	2.88	3.10	2.82	3.07
T-Test	N/A	0.79		0.05*		0.81		0.65	
Compensation encourages cooperation between ranchers and wildlife conservation									
N =	18	9	9	10	8	14	4	9	9
Mean	2.89	3.00	2.78	3.00	2.75	2.71	3.50	3.11	2.67
T-Test	N/A	0.61		0.54		0.18		0.46	

* Statistically significant at 90% confidence level.

** Statistically significant at 95% confidence level.

*** Wilcoxon Two-Sample T-Test.

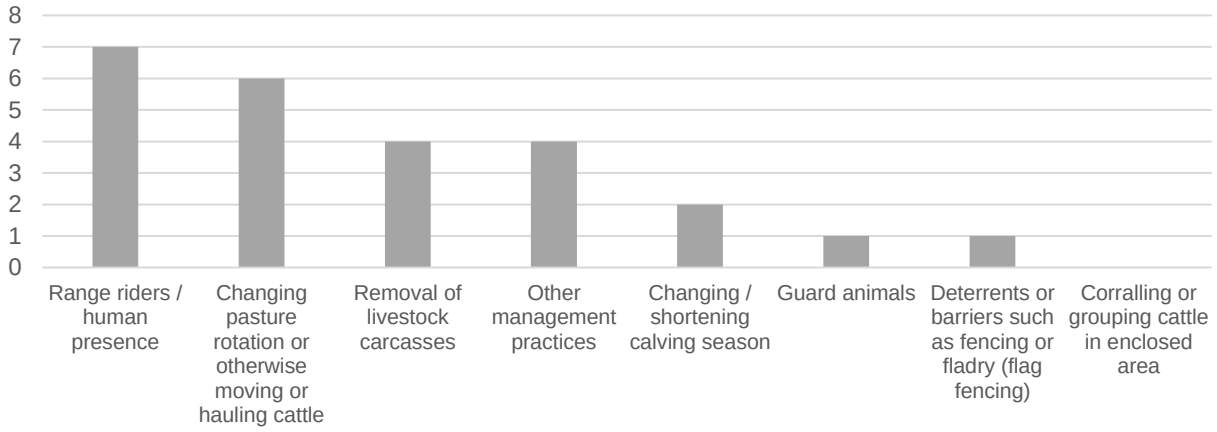

Figure 3. Management practices employed by Arizona ranchers to avoid or reduce livestock-wolf conflicts.

Preventative Management Practices

Of 28 respondents, 12 indicated using preventative practices to help avoid or reduce wolf depredation and impacts. Of those 12, eight had experienced wolf impacts, three had not, and one was unsure (Table 3). Of the eight respondents that had both experienced wolf impacts and indicated using preventative practices, seven reported estimates of depredation levels and spending for preventative practices. Only three respondents that had experienced wolf impacts indicated that they had not adopted preventative practices. Two of these ranchers indicated they believed preventative practices were not effective at reducing livestock depredations.

Table 3. Adoption of preventative management practices by wolf impact on ranch.

Ranch Impacted by Wolves?	Management Practices?		
	Yes	No	Total
Yes	8	3	11
No	3	11	14
Unsure	1	2	3
Total	**12**	**16**	**28**

Among respondents using preventative practices, the most commonly adopted practice was use of range riders (Figure 3). Five respondents reported their spending on range riders, which averaged between $5,700 and $6,000 per year, depending on the year, and ranged from $500 to $9,000 across respondents.

Changing pasture rotation or moving or hauling cattle to another location was the second most commonly used practice (six responses). Spending ranged from $1,000 per year to more than $15,000 per year. Third was removal of livestock carcasses (four responses), with spending ranging from $300 to $700 per removal, and other types of management practices (four responses). Other practices reported by ranchers include making changes to the calving season and changing which heifers are kept as replacements. Other notable practices were purchasing feed for cattle moved off their range, reported to cost as much as $20,000 to $30,000 per year. The most expensive management practices were purchasing additional feed and supplements, hauling or moving cattle, and employing range riders. Total costs vary significantly by operation and depend on practices used and ruggedness and remoteness of the ranch. Total spending by ranch ranged from $500 to $52,000 in 2016 (Table 4). Per cow, this ranged from under $8 to more than $184 per cow.

Table 4. Costs of management practices used to reduce wolf depredation risk, 2016.

	Total Spent	Cost Per Cow
Minimum	$500	$7.83
Median	$8,800	$30.00
Average	$19,507	$63.55
Maximum	$52,000	$184.25

Ranchers also reported the time they spent implementing preventative practices. Cost of time was calculated as respondent reported hours multiplied by the 2016 median hourly wage for farmers, ranchers, and other agricultural managers (Occupation Code 11-9013) in Arizona (BLS 2017). Time invested per year ranged from 172 hours to 1,555 hours, or roughly 30 hours per week. On a per-cow basis, this ranged in cost from just under $15 to nearly $300 per cow (Table 5). Combined, respondent-reported spending per cow for preventative practices ranged from about $34 to more than $440 per cow (Table 6).

Table 5. Costs of rancher time for implementation of preventative management practices, 2016.

	Hours	Cost of Time	Cost per Cow
Minimum	172	$5,714	$14.76
Median	280	$9,302	$42.28
Average	528	$17,535	$111.57
Maximum	1,555	$51,657	$283.59

Ranch Return Scenarios

Finally, we compare respondent-reported spending on preventative practices, including the value of ranchers' time, with net returns per cow under three different sales price scenarios (i.e., a low-price, mid-price, and high-price year) and under different calf depredation scenarios. We examine net returns assuming no wolf effects (0% calf depredation) and assuming the maximum respondent-reported level (13% calf depredation). We also estimate the calf depredation level that would have to occur in order

Table 6. Comparison of management expenses and net returns in low-, mid-, and high-sales price years.

Ranch	Herd Size	Management Expense +Time	LOW PRICE YEAR		MID PRICE YEAR		HIGH PRICE YEAR	
			Net Returns/ Cow	Net Returns Less Management Expenses	Net Returns/ Cow	Net Returns Less Management Expenses	Net Returns/ Cow	Net Returns Less Management Expenses
A	250	$126.00	$83.33	-$42.67	$245.30	$119.30	$407.27	$281.27
B*	800	$93.24	$251.71	$158.47	$471.81	$378.57	$691.91	$598.67
C*	115	$57.51	$208.35	$150.84	$413.48	$355.96	$618.61	$561.09
D	450	$34.32	-$57.35	-$91.67	$56.06	$21.74	$169.46	$135.14
E	41	$295.78	-$18.74	-$314.52	$107.99	-$187.79	$234.72	-$61.06
F	200	$64.88	-$0.91	-$65.79	$131.98	$67.10	$264.86	$199.98
G	200	$442.54	$161.80	-$280.73	$350.86	-$91.67	$539.92	$97.39

* Ranch reports the sale of yearlings in addition to calves.

Table 7. Net returns less management expenses in low-, mid-, and high-sales price years.

Ranch	Net Returns Less Management Expenses Given Maximum Reported Depredation Rate (13%)			Depredation Rate Required to "Break Even" on Preventative Expenses in High Price Year
	LOW PRICE YEAR	MID PRICE YEAR	HIGH PRICE YEAR	
A	-$342.94	-$284.63	-$226.32	36%
B	$85.86	$280.90	$475.93	63%
C	$96.56	$282.95	$469.34	81%
D	-$134.37	-$35.71	$62.95	24%
E	-$362.25	-$251.99	-$141.73	0%
F	-$113.48	$2.94	$119.36	32%
G	-$350.17	-$185.08	-$19.99	11%

for ranchers to "break even" on their reported level of preventative practice spending in a high price year.

Results show that in a low-sales price year, net returns per cow are negative for three of seven ranches (D, E, and F) regardless of whether the rancher spent on preventative management practices (Table 6). In this case, any spending on preventative management practices would exceed the net returns the rancher would expect to receive. For ranches A and G, spending also exceeds net returns in a low-price year, though the ranchers can invest in some level of preventative management practices and still maintain positive returns. For example, in a low-price year, ranch A spends $126 per cow in preventative management practices to protect $83.33 in net returns per cow. The same level of spending in a mid- or high- price year, however, results in positive net returns for ranch A. In those cases, ranch A spends $126 per cow in preventative management practices to protect $245.30 and $407.27 per cow. Whereas ranches D and F spend at levels that result in positive net returns in the mid- and high- price years, ranch E consistently spends more than net returns (even in a high-price year, ranch E spends $295.78 to protect net returns of $234.72). The two ranches reporting the highest preventative management spending per cow (E and G) are also the ranches with negative returns under the mid-price scenario. Only two ranches (B and C) obtain positive net returns per cow under all price scenarios. This is likely because these ranches reporting selling yearlings as well as calves.

We also examine net returns versus reported spending on preventative management practices under the maximum respondent-reported calf depredation rate (13%) for low-, mid-, and high-sales price years (Table 7). At 13% calf depredation, only ranches B and C maintain positive net returns accounting for preventative management spending. This is the case for all three price scenarios. Whereas only one ranch has negative net returns after preventative management spending is taken into account in a high-price year (E), when calf depredation levels reach the reported maximum of 13%, three of seven ranches experience negative net returns (A, E, and G).

Finally, we estimate the calf depredation level that would be required for ranches to "break even" on their preventative management spending in a high price year, in other words, the minimum level of depredation that would have to be avoided for preventative measures to produce a positive return. Depredation rates range from 0% (where the ranch is already spending above the returns per cow without calf depredation) to 81% (Table 7).

These results suggest that while in some cases rancher investment in preventative management practices conforms with the basic assumptions that a rancher will not spend in excess of the net returns they expect to receive, in other cases ranchers spend more, suggesting that investment in preventative management practices is not solely dependent on financial outcomes. Furthermore, in years

where there are low calf sale prices, from a strictly financial standpoint, it might not be beneficial to invest in any preventative management practices.

DISCUSSIONS

Implications

In assessing rancher response to wolf presence through investment in preventative management practices, we find that while ranch profits are an important factor in decision making, spending on preventive practices can be large relative to returns, particularly in low-price years. Some ranchers may be influenced by their perception of risk and respond to maximum reported depredation rates, though others may be influenced by factors outside of the profits of their ranch. Additionally, we analyze differences in attitudes towards wolf presence and wolf reintroduction across a series of rancher characteristics. Our results are, at times, counterintuitive. For example, we find that attitudes towards wolves and their reintroduction are more negative among ranchers that have not been affected by them in the past and among ranchers not located within their reintroduction area.

These results point to the complexity of the conflict, which goes beyond financial losses and is in part rooted in social and cultural identity. Both results have important implications for conservation efforts. First, with attitudes rooted in social and cultural identity, compensation may not be effective in shifting acceptance towards reintroduction and increasing cooperation between conservationists and ranchers. Second, compensating ranchers for the value of depredated livestock may be insufficient to make them "whole." Past research suggests that rancher utility may be dependent on the productive potential of their ranch as well as its consumptive value in terms of lifestyle benefits and amenity values. To the extent that the non-monetary benefits that ranchers receive from ranching are impacted by predator reintroduction, those losses have gone uncompensated under past compensation programs.

Some limitations of our analyses include the relatively small sample size, though it covers a high percent of affected ranchers. Areas for future research include better understanding the effectiveness of preventative management practices under different physical conditions and scenarios. This would better inform understanding of rancher decision-making and programs that compensate producers for investment in preventative management practices. Though challenging to fully capture, more information on depredation rates and the spatial variability of depredation over time could help to better understand impacts of wolves on individual operations and the risk to nearby producers. Finally, willingness to pay to avoid depredation may be an area for future research to help quantify the impacts of predator reintroduction on non-monetary benefits of ranching.

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