Effects of Depredation & Mexican Gray Wolf Presence on Ranch Returns:

Case Study of a Representative Ranch in Arizona

Update to 2018 Study

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This report presents an update to the 2018 study "Effects of Depredation and Mexican Gray Wolf Presence on Ranch Returns: Case Study of a Representative Ranch in Arizona" (Bickel et al., 2018) and thus borrows heavily from previous content and language developed by A. Bickel.

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Executive Summary

What is the study about?

This report updates the 2018 study "Effects of Depredation and Mexican Gray Wolf Presence on Ranch Returns: Case Study of a Representative Ranch in Arizona" (Bickel et al., 2018). In that study, a representative ranch model was used to simulate the effects of wolf presence on short-term ranch returns for a representative Arizona ranch under a range of scenarios (wolf depredation of cattle, cattle weight loss, additional management costs, etc.). Additionally, it presented an analysis of long-term effects on ranch profitability that could be capitalized into ranch values. Since that study was conducted, conditions have evolved, including the minimum Mexican gray wolf population in the wild, prevailing cattle prices, agricultural input prices, and existing compensation programs. This new study incorporates updated market prices, considers compensation schemes currently available to producers, and combines input from the original survey of affected Arizona ranchers from the 2018 study with responses from a newly-conducted rancher survey.

What did the study find?

Impacts of wolves on Arizona ranching operations

- While generally at a county or state level, the impacts of wolves are not detectable, a small number of individual cattle ranching operations are heavily impacted by wolf depredation year after year. This finding is consistent with other studies that have found that a small number of producers are heavily impacted while most others experience small impacts or no impacts.
- Nine (9) of 24 Arizona survey respondents report direct impacts of wolf presence through depredation of cattle. 5 respondents reported indirect weight loss impacts only, and 9 reported not experiencing any wolf impacts.
- Wolf depredation of calves reduces ranch revenues by decreasing the number of calves available to sell. The loss of a cow, however, has a multi-year impact equal to the loss of two calves that would have been born had it not been depredated.
- Ranchers report that in addition to direct depredation, wolf-related stress reduces weight gain in calves, leading to lower sale weights, an effect that can occur across the herd.
- Compared to a baseline of no wolf presence, a combination of wolf depredation and wolf-related weight loss can reduce representative ranch revenues by 7% under combined 2% calf depredation and 2% calf weight loss, to a 46% reduction under combined 14% depredation and 10% weight loss. Previous survey responses suggest that, of those affected by wolves, average wolf effects are 2% calf depredation and 3.5% weight loss (Bickel et al., 2018).
- When ranchers incur additional management costs to deter wolf presence, that further reduces ranch returns. For example, combining 2% depredation, 2% weight loss, and average preventative expenditures per cow reduces representative ranch revenues by 19%.

Arizona rancher attitudes towards Mexican wolves and compensation programs

- Arizona ranchers responding to the survey generally agree that the health of their ranching operation is tied to the health of the ecosystem, though views are mixed regarding whether predators are part of a healthy ecosystem.

- Arizona respondents overwhelmingly agree that too much responsibility for ensuring populations of threatened and endangered species is borne by ranchers, and respondents are strongly in opposition to maintaining a healthy wild population of Mexican wolves.
- Arizona ranchers responding to the survey strongly agree that Mexican wolf depredation is a more serious problem than depredation by other large predators, and that Mexican wolf presence is a threat to the ranching way of life.
- Respondents held mixed views regarding whether the economic impacts they have experienced from Mexican wolves are tolerable, and whether they would be more accepting of Mexican wolf presence if compensation covered its full direct and indirect costs.
- Responding Arizona ranchers generally disagree that compensation is adequate to cover the full costs of depredation-related losses (including direct and indirect effects). Respondents generally agree that compensation programs place too much burden of proof on ranchers and that compensation is not timely
- There were mixed responses regarding whether compensation encourages cooperation between ranchers and wildlife conservation, whether compensation is worth the effort, and whether compensation procedures and requirements are too complex.

Compensation programs

- In cases where depredation is confirmed, current Arizona compensation policies are generally sufficient to cover the direct revenue loss of depredated calves and cows.
- However, if rancher time spent filing for compensation is included in the losses due to depredation, the current Arizona compensation scheme may undercompensate the loss of time, particularly in the case of a depredated cow.
- Generally, the current Arizona compensation scheme is not sufficient to cover the combined effects of multiple depredations, calf weight loss, as well as lost time filing for compensation.
- These results are contingent on depredations being confirmed. If a true wolf depredation is not confirmed due to decay of the carcass, a missing carcass, or other obstacles, that depredation goes fully uncompensated.

Longer-term effects on ranch property values

- The sales value of a working ranch depends on a combination of the production value of ranch operations and other aesthetic or location-specific features of the ranch itself that affect its value as a residential property. Wolf depredations may be expected to be capitalized into the production value portion of the ranch property value.
- Compared to a baseline of no wolf depredation and no stress-related weight loss, the net present value of the production value of the ranch is modeled to decline by $191,000 over 30 years in the "average" 2% calf depredation, and 3.5% calf weight loss scenario. This decline may be expected to factor in the sales price (and 30-year mortgage) of a ranch.

County-level impacts

- For Arizona counties in the Blue Range Wolf Recovery Area (BRWRA), ranching represents a small proportion of the county economy (as measured by Gross Domestic Product - GDP). Moreover, for most agricultural operations, ranching and farming are not a major source of household income. For this reason, severe depredation impacts on individual ranches may not show up in aggregate, county-level statistics.
- Statistical analysis comparing cattle and calf inventories between counties with greater wolf presence and those with low or no presence found no statistically significant reduction in inventories in high-presence counties compared to low-or-no-presence counties.

- Similar analysis of livestock sales found that sales in Catron County, New Mexico did have statistically significant, lower sales than low-to-no presence counties. This negative effect was not found for Arizona counties.

How was the study done?

The analysis uses a representative ranch herd planning model to examine the financial impact of different wolf effect scenarios on a representative cow-calf ranching operation in Eastern Arizona. We examine the effects of both a single calf depredation and a single cow depredation on herd dynamics, along with the impacts on short-run annual cash returns under different levels of wolf depredation and stress-induced weight loss across the herd. Finally, we conduct a long-term analysis of returns over total cost across 30 years, including a projection of future costs and returns. Long-term returns over total costs represent a measure of the ranch's revenue-generating potential as it would be capitalized into ranch property values. We also present the results of a rancher survey, reporting on Arizona rancher attitudes towards wolf presence and compensation programs. Finally, we conduct an analysis of county livestock performance to test for any regional-level effects of wolf presence on the cattle ranching industry.

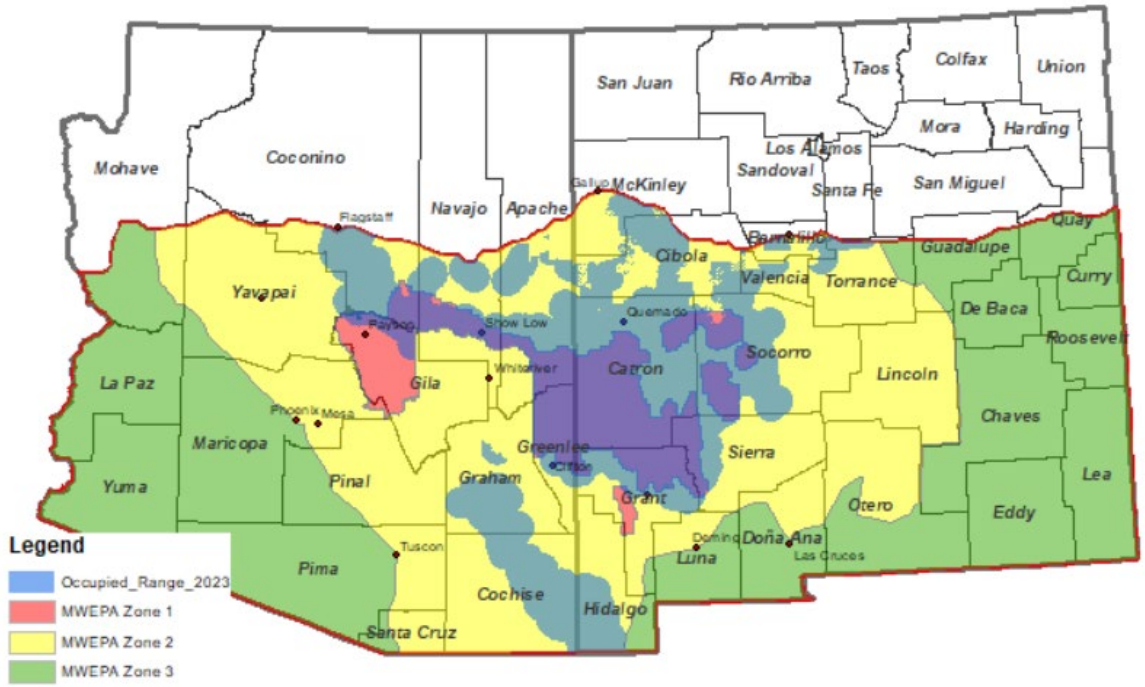
Introduction & Background

This report presents an update to the 2018 study "Effects of Depredation and Mexican Gray Wolf Presence on Ranch Returns: Case Study of a Representative Ranch in Arizona" (Bickel et al., 2018). In that study, a representative ranch model was used to simulate the effects of wolf presence on short-term ranch returns under a range of scenarios (wolf depredation of cattle, cattle weight loss, additional management costs, etc.). Additionally, it presented an analysis of long-term effects on ranch profitability that could be capitalized into ranch values. Since that study was conducted, conditions have evolved, including the minimum Mexican gray wolf population in the wild, prevailing cattle prices, agricultural input prices, and existing compensation programs. This study offers an update to the previous analysis, incorporating updated market prices, considering compensation schemes currently available to producers, and incorporating input from both a newly conducted survey and the original survey of affected Arizona ranchers applied for the 2018 study.

Livestock production has occurred for well over a century in the area now designated as the Blue Range Wolf Recovery Area (BRWRA) (Mars et al., 2021). Wolves were extirpated from this area in the 19th and early 20th centuries through efforts to eliminate predators affecting livestock production. The Mexican wolf was listed as endangered in 1976 (U.S. Fish and Wildlife Service, 2014a) and the Mexican Gray Wolf Recovery Program soon followed. An experimental population was first introduced into the wild within the BRWRA in 1998.

The reintroduction area now includes areas in Arizona and New Mexico south of Interstate-40 to the Mexican border (Figure 1). Within this area, reintroduction is concentrated within the Mexican Wolf Experimental Population Area (MWEPA) Zone 1. In 2022, based on the documented range of collared animals, occupied areas include MWEPA Zones 1 and 2. Most recent wolf locations are concentrated in MWEPA Zone 1 which spans areas of the Gila National Forest in New Mexico and the Apache-Sitgreaves National Forest in Arizona.

FIGURE 1. MEXICAN GRAY WOLF ESTIMATED EXTENT, 2023*

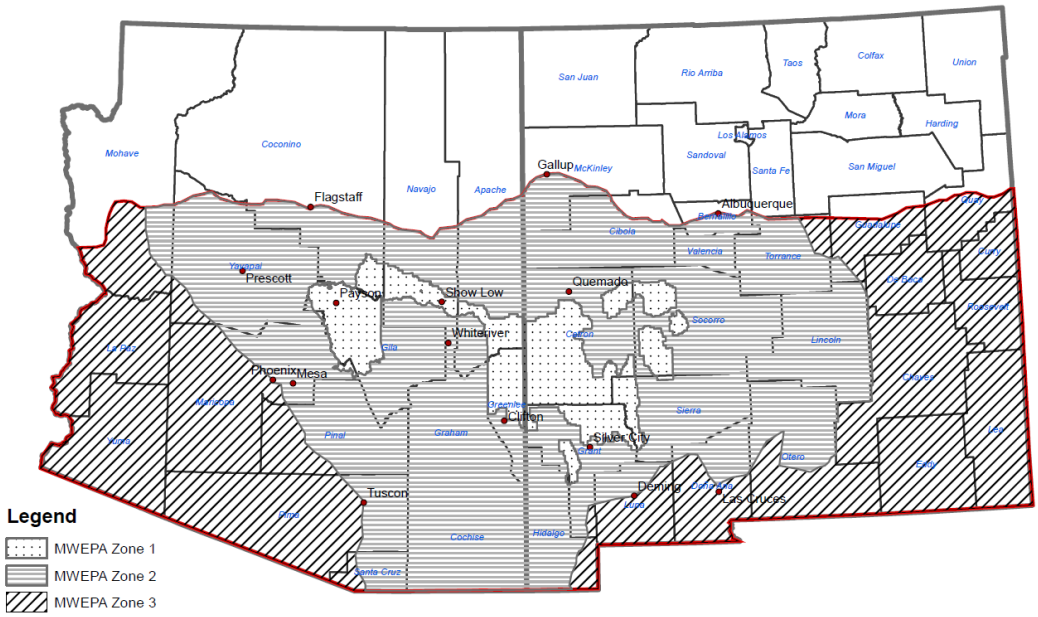


Source: U.S. Fish & Wildlife Service; *Note: Red area depicts MWEPA Zone 1, yellow area depicts WEMPA Zone 2, green area depicts MWEPA Zone 3. Blue overlay area depicts 2022 detected range of Mexican wolves.

Study Area

The study area consists of portions of Eastern Arizona and Western New Mexico. The Mexican Wolf Experimental Population Area (MWEPA) is divided into three zones (Figure 2). Zone 1 represents the area where reintroduction efforts were first focused in the late 1990s.

FIGURE 2. MEXICAN WOLF EXPERIMENTAL POPULATION AREA ZONES



Source: US Fish & Wildlife Service

The MWEPA includes remote and rugged mountainous areas of Eastern Arizona and Western New Mexico. MWEPA Zone 1 is dominated by U.S. Forest Service lands, including the Apache-Sitgreaves National Forest in Arizona and the Gila National Forest in New Mexico. Cattle sales by county (in number of head sold) in areas most affected by wolves have fluctuated by year without a clear trend over the period since the introduction of Mexican wolves into the wild (Table 1). This, however, represents all cattle ranching operations in the counties and does not reflect effects on individual operations.

TABLE 1. SALES OF CATTLE, INCLUDING CALVES, MEASURED IN HEAD, 1997-2022

State	County	1997	2002	2007	2012	2017	2022
ARIZONA	APACHE	14,485	19,621	11,311	12,920	17,491	14,413
ARIZONA	COCHISE	46,761	44,686	33,329	31,357	41,276	52,067
ARIZONA	COCONINO	22,068	18,917	(D)	(D)	24,596	24,934
ARIZONA	GILA	10,219	5,311	4,121	5,401	7,558	6,784
ARIZONA	GRAHAM	13,306	7,694	5,627	6,171	7,800	7,462
ARIZONA	GREENLEE	5,378	5,084	4,509	5,916	4,324	1,527
ARIZONA	NAVAJO	15,518	11,073	10,453	13,809	11,882	(D)
ARIZONA	YAVAPAI	38,205	29,726	23,405	33,028	23,778	20,751
NEW MEXICO	CATRON	40,403	18,533	16,837	14,641	13,323	20,735
NEW MEXICO	CIBOLA	11,282	8,045	9,462	6,306	7,134	8,476
NEW MEXICO	GRANT	17,016	17,336	14,413	15,023	17,623	14,525
NEW MEXICO	HIDALGO	13,985	12,190	11,614	15,760	15,275	11,821
NEW MEXICO	MCKINLEY	15,826	9,802	13,726	8,662	8,756	5,676
NEW MEXICO	SIERRA	14,565	13,069	12,181	9,051	11,087	6,661
NEW MEXICO	SOCORRO	24,126	22,382	20,930	28,498	18,981	18,677

Source: USDA Census of Agriculture, 1997-2022. *(D) – Not disclosed to protect confidentiality of individual operations.

When measured in monetary value, again, cattle sales have experienced significant fluctuations between agricultural census years. Sales value, adjusted for inflation, does not show a clear trend across affected counties over time. Some counties experienced an increase over time, others a decrease, and others remained steady (Table 2).

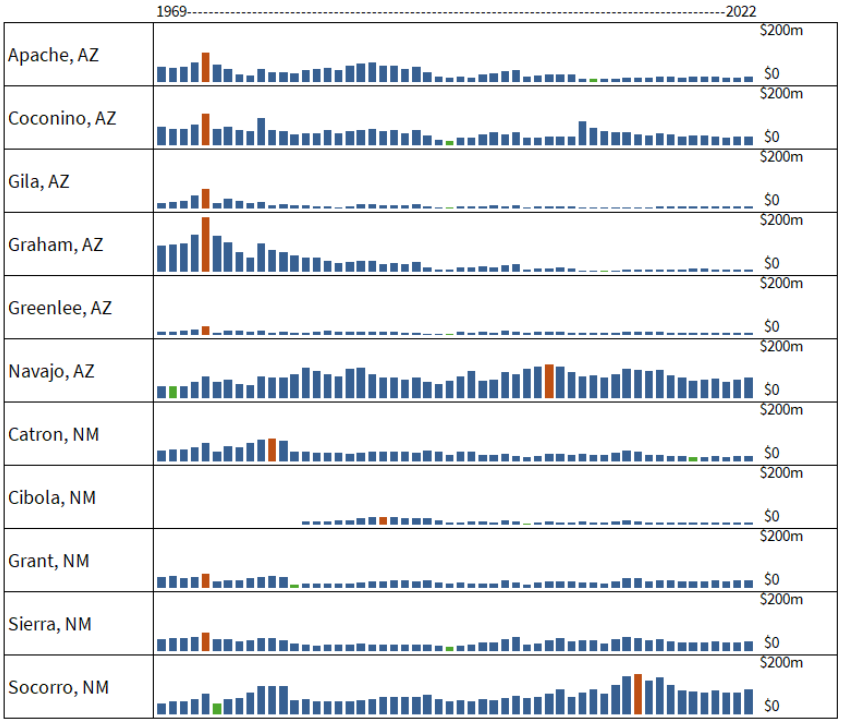
TABLE 2. SALES OF CATTLE, INCLUDING CALVES, MEASURED IN 2024 DOLLARS, 1997-2022

State	County	1997	2002	2007	2012	2017	2022
ARIZONA	APACHE	$11,242,817	$12,983,595	$9,398,909	$12,132,045	$15,139,884	$11,114,342
ARIZONA	COCHISE	$35,115,703	$35,731,929	(D)	(D)	$37,286,413	(D)
ARIZONA	COCONINO	$19,096,744	$14,759,637	(D)	$26,129,396	$25,834,843	$19,351,206
ARIZONA	GILA	$6,895,177	$3,897,521	$3,741,532	$4,221,336	$7,447,041	$6,211,144
ARIZONA	GRAHAM	$10,090,359	$6,633,113	$4,972,181	$6,097,638	$8,653,008	$6,481,240
ARIZONA	GREENLEE	$4,042,405	(D)	(D)	(D)	(D)	$1,819,426
ARIZONA	NAVAJO	$12,937,261	(D)	(D)	(D)	(D)	(D)
ARIZONA	YAVAPAI	$30,153,680	(D)	$18,292,937	$35,541,147	$22,565,161	$18,778,049
NEW MEXICO	CATRON	$28,492,498	$13,803,575	(D)	$15,957,502	$11,306,905	$17,356,324
NEW MEXICO	CIBOLA	$8,648,321	$5,268,807	$6,335,060	$6,226,849	(D)	$7,850,860
NEW MEXICO	GRANT	$13,823,616	$12,819,599	$11,281,696	$16,061,970	$17,695,203	$14,827,630
NEW MEXICO	HIDALGO	$10,861,273	$8,974,417	(D)	(D)	(D)	$10,784,698
NEW MEXICO	MCKINLEY	$13,361,851	$9,018,033	(D)	$8,466,040	$8,217,733	$4,006,778
NEW MEXICO	SIERRA	$10,082,533	(D)	(D)	(D)	(D)	$6,183,496
NEW MEXICO	SOCORRO	$16,868,138	(D)	$17,391,363	$26,448,299	$15,463,780	(D)

Source: USDA Census of Agriculture, 1997-2022. *(D) – Not disclosed to protect confidentiality of individual operations.

Over the longer term, different trends in livestock sales have played out across counties in the affected areas (Figure 3). While some counties in both states have seen declines in inflation-adjusted livestock sales from 1969 to 2022, others have seen an increase over the same period.

FIGURE 3. CASH RECEIPTS FROM SALES OF LIVESTOCK & LIVESTOCK PRODUCTS IN ARIZONA & NEW MEXICO COUNTIES WITH WOLF PRESENCE (2022 USD), 1969-2022

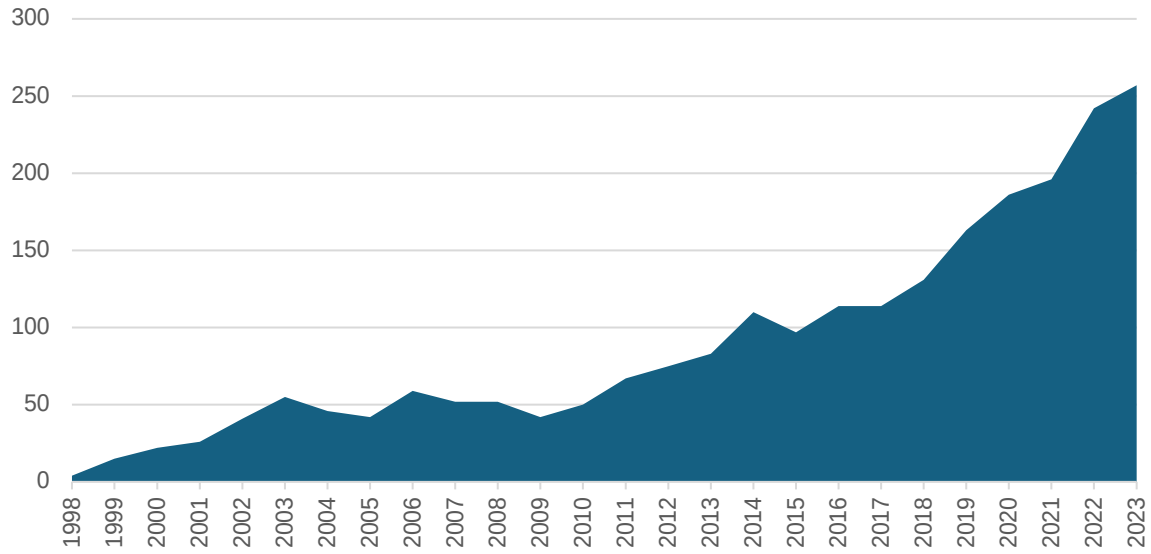


Source: Bureau of Economic Analysis. * Red bars indicate the year with the highest sales, and green bars indicate the year with the lowest sales.

Wolf Population

Since 2016, the minimum population of Mexican gray wolves in the wild within the U.S. has roughly doubled (Figure 4). As of the end of 2023, there were an estimated minimum of 257 Mexican wolves in the wild (113 in AZ and 144 in NM) (USFWS, 2024).

FIGURE 4. MEXICAN GRAY WOLF MINIMUM POPULATION IN THE WILD (ARIZONA & NEW MEXICO), 1998-2023

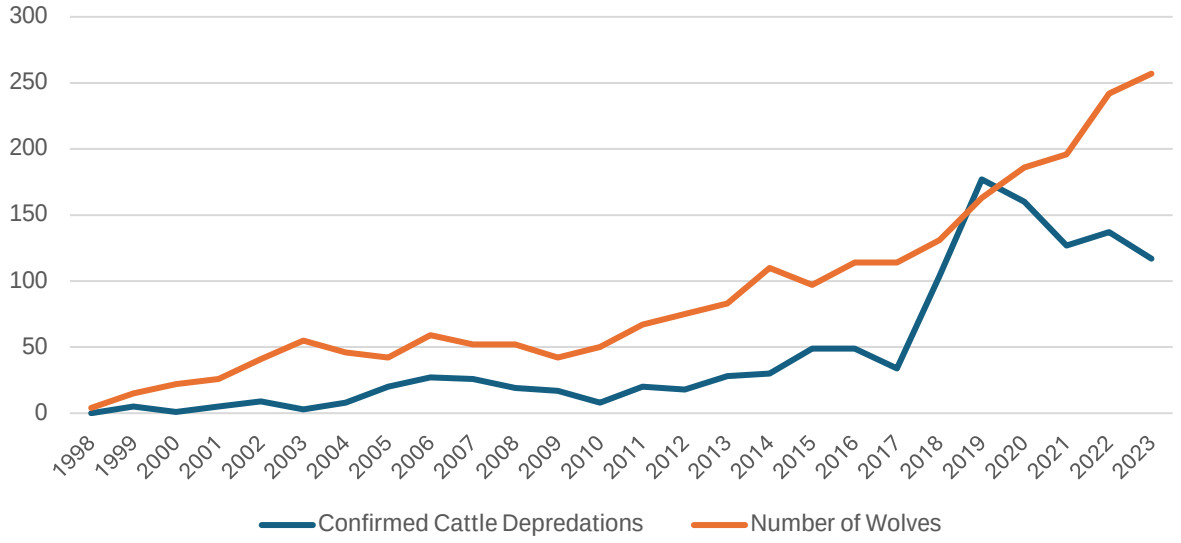


Source: USFWS Annual Reports, multiple years

Efforts to reintroduce the Mexican gray wolf into the area have been met with significant concern by cattle ranchers, particularly around the potential negative economic impacts that wolves may have on ranching in the area. The effects of wolves on ranching include the direct effect of depredation of livestock (death or injury), indirect physiological effects of stress on livestock due to wolf presence (weight loss), increased operating costs including spending on measures to prevent or reduce wolf-livestock conflict, and potential long-run effects on ranch property values.

With the increasing wolf population in the wild, total confirmed depredations have increased as well, with year-to-year fluctuations (Figure 5). Following 2017, there was a sharp increase in confirmed depredations, and then a sharp decrease beginning in 2020 which has since continued to the present.

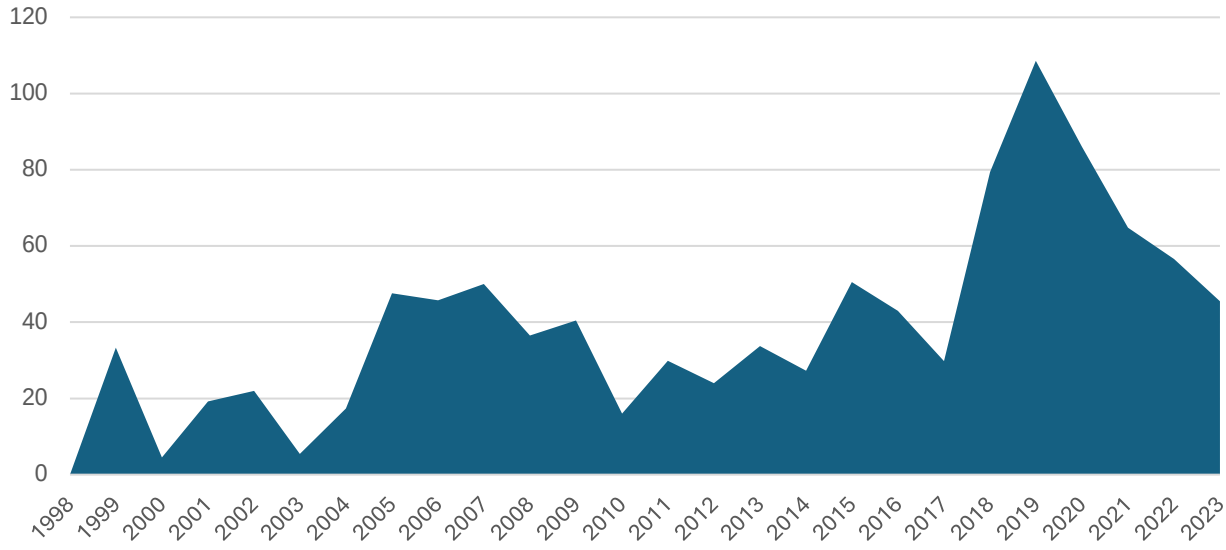
FIGURE 5. CONFIRMED DEPREDATIONS VS. MINIMUM WOLF POPULATION (ARIZONA & NEW MEXICO), 1998-2023



Source: USFWS Annual Reports, multiple years

Figure 6 presents the number of confirmed depredations per 100 wolves (based on the estimated minimum population in the wild). The number of confirmed depredations per 100 wolves remained at or below 50 until 2018, after which the number exceeded 50, peaking in 2019 at 108 confirmed depredations per 100 wolves.

FIGURE 6. CONFIRMED DEPREDATIONS PER 100 WOLVES (ARIZONA & NEW MEXICO COMBINED)



Source: USFWS Annual Reports, Author calculations

Confirmed depredations per wolf are a function not only of the level of depredation, but also the depredation confirmation process. All else held constant, if standards of proof are changed to be more or less stringent in their requirements, the level of confirmed depredations would be expected to change accordingly. Ranchers

report recent tightening of standards around proving depredations[1], in particular in reference to reliance on subcutaneous hemorrhage as evidence of wolf depredation (Regulation.gov, 2024).

Effects of Wolves on Ranching Operations

Direct Losses: Depredation

The presence of wolves affects cattle ranchers in and around the BRWRA first and foremost through depredation of livestock, including death and injury of ranch animals. Confirmed depredations have increased over time as the wolf population has grown (USFWS, 2022). Generally, calves are more susceptible and more commonly depredated than cows or bulls (Oakleaf et al., 2003; Breck et al., 2011; Sommers et al., 2010). Nonetheless, cows do account for some confirmed depredation events and, rarely, bulls are depredated (Defenders of Wildlife, 2010b). Ranchers also report depredation of ranch animals such as horses and working dogs (Bickel et al., 2018; Muhly & Musiani, 2009).

Past studies have considered the multi-year effect of depredation of cows on ranch returns (Anderson, 2022; Anderson et al., 2014; Conley et al., 2017). Except for cows soon to be culled, the death of a cow or heifer not only results in the loss of the animal, but also the loss of current and future calf production from that animal (Colorado State University Extension, 2020). Area ranchers report retaining calves or heifers as replacements for those cows lost to wolf depredation (Bickel et al., 2018), and therefore fewer calves are available to sell during the time before the retained animal reaches reproductive maturity. That loss is in addition to the loss of the animal itself which would eventually be sold at the end of its reproductive life. In such cases, compensation for the loss of the cow based on its market value alone is insufficient to offset the multi-year impact on ranch returns (Anderson et al., 2014; Ramler et al., 2014). The option of purchasing a replacement cow is often undesirable due to a new animal's lack of familiarity with the area's rugged terrain and climate (Anderson et al., 2014; Ashcroft et al., 2010). Therefore, ranchers typically choose to retain a heifer.

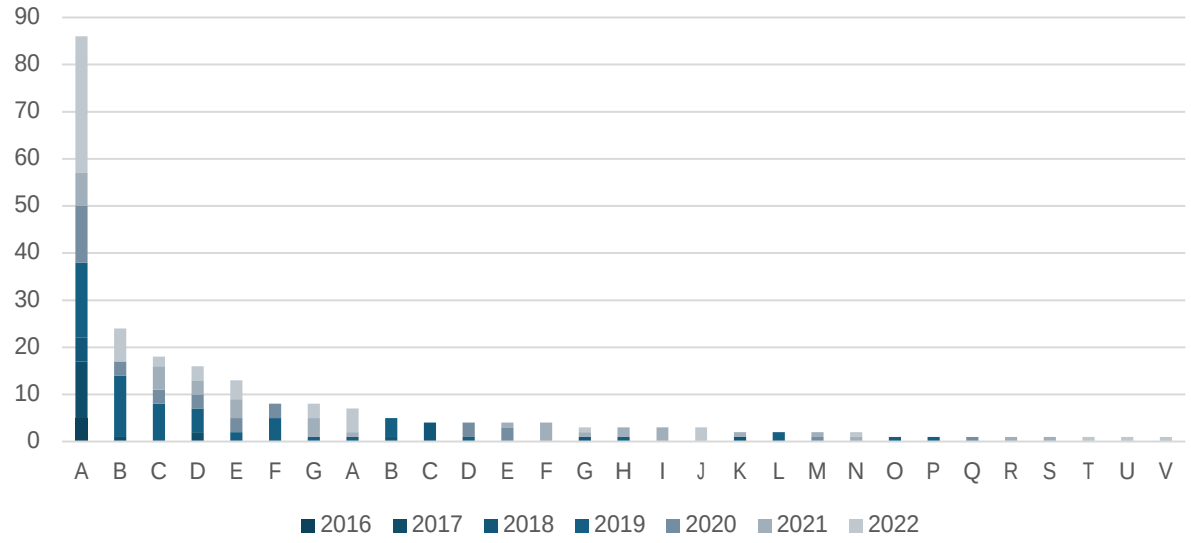
Detecting, locating, and confirming the loss of livestock due to wolf depredation is a major obstacle for ranchers (Oakleaf et al., 2003; Sommers et al., 2010; Breck et al., 2011). Across expansive ranges of rugged and remote terrain, locating carcasses in a timely manner is often not possible (Nickerson et al., 2024). In the case that a missing calf or cow is located, determining that wolves were responsible for a depredation is another challenge. Once animals have been exposed for an extended period, finding reliable bite-marks that allow for the determination of the predator is challenging or often infeasible (Macon, 2020). To account for the potentially large number of depredations that go unconfirmed and therefore uncompensated, some have suggested compensating at a ratio greater than one per confirmed depredated animal (Oakleaf et al., 2003; Sommers et al., 2010). Some programs have used compensation ratios to compensate ranchers in the past (Harris and Fish, 2020), for example, using a ratio of 2:1 in Washington (Washington Department of Fish & Wildlife, 2018), and a ratio of 7:1 in Wyoming (Bickel et al., 2018). Arizona does not use a compensation ratio in determining compensation rates for confirmed depredations.

The magnitude of depredation for individual ranching operations has been estimated at 1.2% (Oakleaf, et al., 2003) and 1.9% (Sommers et al., 2010) and between 0% and 25% (Lee et al., 2016). According to Lee et al. (2016), an estimated 2.6% of producers experienced calf depredation rates of 10% or higher. This suggests that high levels of depredation are uncommon among producers, but those few producers who experience larger impacts may be heavily affected. Figure 7 presents the number of confirmed, compensated depredations among individual producers in Arizona from 2016 to 2022, anonymized. While most producers who have experienced depredation and received compensation experience occasional depredation events, a small number of producers are heavily affected. These producers experience numerous losses year after

[1] See https://usdaoig.oversight.gov/sites/default/files/reports/2024-11/Inspection-33801-0001-31-Final-Report.pdf

year. This demonstrates the heavily skewed distribution of depredation among ranches, consistent with previous studies (e.g. Clark et al., 2020; Scasta et al., 2017).

FIGURE 7. CONFIRMED, COMPENSATED DEPREDATIONS BY INDIVIDUAL RANCHES IN ARIZONA, 2016-2022



Source: Arizona Livestock Loss Board

The most important risk factors associated with livestock depredation by wolves include variation in forest canopy cover and abundance of elk, followed to a lesser extent by open terrain and distance from roads and development (Amirkhiz et al., 2018). Elk comprises the large majority of Mexican gray wolf consumption of native ungulates. A recent study found that elk accounted for 94% of native ungulate kills by Mexican gray wolves in the MWEPA and 96% of native ungulate biomass consumed, with mule deer making up the remaining 6% and 4% (Smith et al., 2023). Roughly two-thirds of native ungulate kills were elk calves, as opposed to adult elk.

Indirect Losses: Physiological Impacts

Whereas depredation affects individual animals or small groups of animals, the stress effects of wolf presence may affect animals across an entire herd of cattle (Martin et al., 2020). The chronic stress associated with the presence of predators may reduce weight gain, conception rates, and affect animal behavior (Gese et al., 2020; Howery & DiLiberto, 2004; Lehmkuhler, 2007; Ramler et al., 2014; Cooke, 2014). Such effects result in negative impacts on ranch profitability (Bickel et al., 2020). Research quantifying these effects finds stress responses are present in herds that have directly experienced a depredation event in the past, but not in those in proximity to wolf ranges that have not directly experienced a depredation (Ramler et al., 2014; Cooke, 2014). One study found that herds having experienced direct depredation had calf weaning weights 3.5% (22 pounds) lower than herds not having experienced direct depredation (Ramler et al., 2014).

Additional Management Costs

Ranchers operating in areas affected (or potentially affected) by wolf presence may incur additional management costs to prevent depredation, or to respond to depredation incidents (Bogezi et al., 2021; Bruns et al., 2020). Proactive management measures include:

- altering the grazing rotation of livestock to move them to different allotments less affected by wolves;
- removal of livestock carcasses that could attract wolves;
- placement of diversionary food caches to draw wolves away from areas where livestock are located;

- containment of livestock in smaller protected areas during vulnerable times while feeding hay and supplements in lieu of grazing open pasture;
- hazing wolves to encourage them to leave an area;
- employing range riders to monitor herds through human presence;
- installation of turbo fladry to scare wolves away from fenced pastures; and
- collaring and radio telemetry monitoring of wolves to inform livestock producers when wolves are in proximity to grazing areas (Miller et al., 2016; USFWS, 2023; Plotsky et al., 2024; Wilkinson et al., 2020).

When the producers adopt these preventative practices, the expenses for operations increase. Additional materials or feed may be required, range riders or other labor may need to be hired, and additional fuel expenses and vehicle depreciation may be incurred (Anderson et al., 2024). Further, the time dedicated to proactive management practices may lead to deferred maintenance of ranch facilities and infrastructure (Harris & Fish, 2020).

When depredation incidents do occur, ranchers who intend to seek compensation must locate the carcass, coordinate with authorities to perform an investigation of the incident, and complete the required paperwork, often facing logistical challenges (Bogezi et al., 2021; van Eeden et al., 2021). One study estimated that 10 hours are required for this process (Thompson, 1993). Ranchers report that in some cases applying for compensation is not worth the time and effort given the uncertain outcome of investigations or when the amount of time lapsed since the depredation could compromise the ability of investigators to determine a cause of death (Bickel et al., 2018; Macon, 2020).

Ranch Property Values

Whereas lost revenues and increased costs incurred affect ranch profitability on a year-to-year basis, the sustained presence of wolves may affect ranch property values through impacts on the longer-term financial viability of ranch operations as well as impacts on ranch amenity values.

Ranch values may reflect diverse values of the land. Ranches provide amenity values to their owners, for example, the ability to enjoy the ranching lifestyle, the scenic quality of the land, and tax benefits, among others (Torell et al., 2001). While the revenue-generating potential of a ranch explains a relatively small portion of its overall value, it remains one of several contributing factors to ranch value (Torell et al., 2005). Insofar as wolf presence impacts the profitability of ranching, those impacts can be capitalized into the value of ranches affected by wolves. This potential change in value can be estimated using the net present value (NPV) of ranch returns over time (Burt, 1986) with and without wolf impacts.

Compensation Programs

Compensation for the effects of Mexican wolves on livestock operations has changed over time. The first compensation program was managed by Defenders of Wildlife, a national non-profit organization dedicated to the conservation of wildlife. The Defenders of Wildlife compensation program was in effect in the BRWRA from 1987 to 2010 and made a total of $115,666 in payments to livestock operations affected by Mexican wolves. That total represents 67 payments compensating losses of 168 cattle, 10 sheep, and 10 other animals depredated or injured in Arizona and New Mexico. Ranchers in Arizona received 33 payments valued at $45,806 (Defenders of Wildlife, 2010b).

In 2010, compensation transitioned from Defenders of Wildlife to Arizona and New Mexico's state governments and was funded through the Mexican Wolf/Livestock Interdiction Trust Fund (Trust Fund). The Trust Fund received monies from federal grants awarded to the Arizona Game and Fish Department and the New Mexico Department of Agriculture through the Federal Wolf-Livestock Demonstration Project and through private, non-federal funds provided by non-governmental organizations such as Defenders of Wildlife and the Mexican Wolf Fund. From 2011 to 2015, more than $500,000 was granted to the Trust Fund as part of the Wolf-Livestock Demonstration Project (Guertin, 2016).

Beginning in 2016, ranchers in Arizona could apply for depredation compensation through the Arizona Livestock Loss Board. The Arizona Livestock Loss Board (ALLB) was established by law (SB1466) in 2015 within the Arizona Department of Game and Fish. The board is comprised of various members including the Director of the Arizona Department of Agriculture, the Director of the Arizona Game and Fish, three individuals representing the livestock industry, two individuals representing wildlife conservation or management, one livestock auction market owner, and one faculty member at one of Arizona's public universities (Arizona Legislature, 2015). In November 2016, the board put in place an interim policy that would allow "ranchers to receive compensation for cattle taken by a Mexican wolf after it is investigated and confirmed by the U.S. Department of Agriculture Wildlife Services field representative" (Arizona Livestock Loss Board, 2016). Suspected wolf depredations must be confirmed by USDA-APHIS Wildlife Services.

An alternative to applying for compensation through the Livestock Loss Board is to seek compensation through the federal Livestock Indemnity Program (LIP), authorized by the Agricultural Act of 2014 (2014 Farm Bill) and administered by the USDA Farm Services Administration (FSA). This program provides "benefits to livestock producers for livestock deaths in excess of normal mortality caused by attacks from animals reintroduced into the wild by the federal government or protected by federal law, including wolves and avian predators" (U.S. Fish and Wildlife Service, 2016). Few producers report using this program for compensation.

Today, compensation programs continue to be managed at the state level through the Arizona Livestock Loss Board in Arizona and the County Livestock Loss Authority (CLLA) in New Mexico. The CLLA was established "by the Boards of County Commissioners of Catron, Sierra, and Socorro County, and was created to ameliorate the disproportionate impacts of the Mexican Wolf Recovery Program on the region" (CLLA, 2025). The CLLA replaced the Mexican Wolf/Livestock Coexistence Council as the entity managing New Mexico livestock producer claims for Mexican wolf depredations and presence and was established with the stated purpose of ensuring more timely payments to compensate for Mexican wolf depredations and presence (CLLA, 2025).

Research has found that past compensation programs have been insufficient to compensate for the loss of cows due to wolf depredation (Andersen, et al., 2014). Compensation at market rate for depredated cows is only appropriate when the cows are soon to be culled from the herd because they no longer have reproductive value to the herd. Otherwise, compensation needs to account for lost production of calves during a window of time when a replacement heifer is retained to replace the lost cow. Ranchers report that for each confirmed depredation, there are often many unconfirmed depredations, or lost animals, the whereabouts of which cannot be determined. This has led to the use of compensation ratios in some states (Oakleaf et al., 2003; Sommers et al., 2010). Generally, ranchers report feeling dissatisfied with current compensation programs, highlighting the reporting process, confirmation processes, and inadequate compensation levels as the main limitations (Nickerson et al., 2024). Generally, the compensation process creates opportunities for under-compensation at a number of key junctures:

1) Locating a depredated animal – if a depredated animal's carcass is not found, there is no evidence to prove the depredation,
2) If the carcass is found, it must be in adequate condition to provide evidence of depredation (not in an advanced state of decay or heavily scavenged),
3) Provided that the carcass is found, the depredation must be confirmed by APHIS-WS or an interagency field team member,
4) If confirmed and compensated, the compensation amount must cover the full costs of depredation on the ranch enterprise, including time spent applying for compensation.

These are only related to the direct effects of depredation and do not consider compensation for indirect effects such as weight loss or spending on conflict avoidance measures.

Compensation for Depredation

A priority of compensation programs for livestock producers has been to offset the direct effects of wolf depredation of cattle, sheep, and other ranch animals. Generally, these programs offer formulas to compensate for the loss of livestock based on their estimated fair market value. The current policy in Arizona is to compensate ranchers at the full fair market value for depredated livestock:

> *"The Claimant can submit the Depredation Form to the ALLB for reimbursement based on a standard calculation approach based on the fair market value at the time of the depredation. In certain circumstances such as the animal being a registered animal, the Claimant can request reimbursement that exceeds the standard calculation based on fair market value for similar animals or actual purchase price."* (Arizona Livestock Loss Board, 2024)

Current ALLB policy compensates for wolf depredations according to the following formula using the national comprehensive boxed beef weekly cutout value from the USDA Agricultural Marketing Service (USDA AMS, 2025) (Table 3):

TABLE 3. ALLB DEPREDATION COMPENSATION FORMULA

Animal	Compensation Formula
Feeder Calf	LM_XB463* Comp. Cutout Value x 7
Yearling	LM_XB463 Comp. Cutout Value x 9
Replacement Heifer	LM_XB463 Comp. Cutout Value x 7 + $750
Cow	LM_XB461** Comp. Cutout Value x 8 + $600
Bull	[Documented value of animal]

Source: Arizona Livestock Loss Board, 2024

*LM_XB463 Comp = National Comprehensive Boxed Beef Cutout – All Fed Steer / Heifer Sales

**LM_XB461 Comp = National Weekly Cutter Cow Cutout & Boxed Beef Values

The formulas are based on prevailing market values for beef, weight factors (7, 8, or 9 representing an average animal weight divided by 100), and investments incurred for animals over a year in age (replacement heifers and cows).

The compensation process requires that individuals seeking compensation initiate an investigation of the depredation by USDA/APHIS-WS to determine the cause of death of the animal:

> *"To receive compensation, a producer/operator (Claimant) shall contact a USDA/APHIS-Wildlife Services Field Representative or Interagency Field Team representative of a depredation incident. An Arizona Wildlife Service Field Representative shall investigate and provide a determination of the cause of death of the livestock in Arizona. Upon completing a determination, the Field Representative shall complete a Depredation Form."* (Arizona Livestock Loss Board, 2024)

Should the investigation determine a probable cause of death due to wolves, the claimant can then proceed to file for compensation which is voted upon on a case-by-case basis by the ALLB and contingent upon funding availability. In Arizona, some funding has become available recently to compensate for probable depredations at half the rate of confirmed depredations (ALLB, 2025). The 2018 study (Bickel et al., 2018) found a range of 6 to 10 hours of rancher time is required to file for compensation. Current compensation programs in Arizona do not compensate producers for the time required to file for compensation.

Compensation has grown over time, consistent with the number of confirmed depredations, peaking in 2019 (Table 4). In Arizona, total compensation peaked in 2022 and has since declined markedly. Anecdotally, producers report that APHIS-WS standards for confirmation of livestock depredation have become more stringent in recent years. These comments are consistent with public comments filed in response to an

APHIS public notice of intent to collect information on livestock producers' perceptions of predator damage management methods (Regulation.gov, 2024).

TABLE 4. DIRECT COMPENSATION FOR LIVESTOCK LOST, ARIZONA & NEW MEXICO, 2011-2024

Year	Direct Compensation for Livestock Lost - Arizona	Direct Compensation for Livestock Lost – New Mexico	Total
2011	$5,400	$12,781	$18,181
2012	$7,550	$15,050	$22,600
2013	$14,581	$13,013	$27,594
2014	$21,100	$42,624	$63,724
2015	$33,070	$77,134	$110,204
2016	$15,785	$58,041	$73,826
2017	$29,880	$29,943	$59,823
2018	$17,850	$92,573	$110,423
2019	$99,312	$185,797	$285,110
2020	$68,306	$105,892	$174,198
2021	$98,016	$80,931	$178,947
2022	$140,014	$62,302	$202,316
2023	$83,556	$58,891	$142,447
2024	$39,163	N/A	N/A

Source: U.S. Fish & Wildlife Service (2024); Arizona Livestock Loss Board

Compensation for Proactive Management

In an effort to promote conflict avoidance, funding has been made available to offset the costs to producers of implementing management practices to deter wolf presence and depredation. In many years, spending on conflict avoidance has exceeded compensation for depredation. Under the current interim depredation prevention policy,

> "*ALLB may provide grants to livestock operators to implement agreed upon measures to reduce wolf depredations. Each grant will require a dollar-for-dollar match from the applicant in the form of cash, in-kind contributions or third-party contributions on behalf of the Applicant. The ALLB will determine the grant payment schedule and term. The awarding of a grant is within the sole discretion of the ALLB and is based on the ALLB's determination of the proposed measures effectiveness at preventing wolf depredation. Based on the ALLB's prior evaluation, preference will be given to applicants that employ range rider strategies. In addition, preference will also be given to projects on ranches that have experienced depredation(s) and those with wolf packs present. Considering preference first, the ALLB will then consider applications in the order received and will award grants until all grant funds are exhausted. To receive grant funding, a livestock producer/operator (Applicant) shall apply to the ALLB on a form prescribed by the ALLB. The Applicant will be required to provide a detailed description of the proposed depredation prevention measure(s) and an itemized cost report showing how the grant monies will be spent (e.g. fencing, range riders, alternative ranges, guard dogs, etc.). If approved, the ALLB will notify the Applicant and forward the approved amount and payment schedule to the National Fish and Wildlife Foundation for payment.*" (Arizona Livestock Loss Board, 2025)

Additionally, since 2023 the ALLB has offered compensation for the removal of livestock carcasses in areas affected by wolves to discourage their presence. The compensation rate is currently $250 per carcass removed.

Under the US Fish & Wildlife Service Wolf Livestock Loss Demonstration Project Grants program, Arizona and New Mexico have received the following funding since 2013 (Table 5).

TABLE 5. USFWS WOLF LIVESTOCK LOSS DEMONSTRATION PROJECT GRANTS, ARIZONA & NEW MEXICO, 2013-2023

Fiscal Year	Arizona	New Mexico
2013	$40,000 $25,403 additional to San Carlos Apache Tribe	$50,000
2014	$80,000	$50,000
2015	$80,000 $70,000 additional to White Mountain Apache Tribe	$34,000
2016	$120,000	$60,000
2017	$100,000 $21,730 additional to White Mountain Apache Tribe	$60,000
2018	$50,000 $23,330 additional to White Mountain Apache Tribe	$60,000
2019/2020	$150,000 $70,000 additional to White Mountain Apache Tribe	$60,000
2021	$150,000	$ 60,000
2022	$83,242	$ 72,103
2023	$120,000	$ 120,000

Source: U.S. Fish & Wildlife Service (multiple years)

These federal monies are distributed through the states and require at least a 1:1 non-Federal match, which can include in-kind matches (Arizona Livestock Loss Board, 2025). Arizona Game & Fish Department and the New Mexico Department of Agriculture apply for the grants and funds are administered through the Arizona Livestock Loss Board and the County Livestock Loss Authority in New Mexico (Arizona Livestock Loss Board, 2025). Compensation granted for conflict avoidance measures in Arizona and New Mexico is presented in Table 6.

TABLE 6. COMPENSATION FOR CONFLICT AVOIDANCE MEASURES, ARIZONA & NEW MEXICO, 2011-2023

Year	Arizona Wolf/Livestock Conflict Prevention	Arizona Wolf/Livestock Pay for Presence	New Mexico Wolf/Livestock Conflict Prevention	New Mexico Wolf/Livestock Pay for Presence	Total
2011	N/A	N/A	N/A	N/A	N/A
2012	N/A	N/A	N/A	N/A	N/A
2013	N/A	$38,000	N/A	$47,500	$85,500
2014	N/A	$38,000	N/A	$47,500	$85,500
2015	N/A	$51,000	N/A	$32,300	$83,300
2016	N/A	$48,000	N/A	$57,000	$105,000
2017	$10,000	$50,000	N/A	$57,000	$117,000
2018	$21,000	$60,000	N/A	$57,000	$138,000
2019	$156,044	N/A	N/A	$57,000	$213,044
2020	$90,000	N/A	N/A	$57,000	$147,000
2021	$94,500	N/A	N/A	$64,877	$159,377
2022	$77,500	N/A	N/A	N/A	$77,500
2023	$142,450	N/A	N/A	N/A	$142,450
2024	$26,250	N/A	N/A	N/A	N/A

Source: U.S. Fish & Wildlife Service (2024); Arizona Livestock Loss Board

Survey Results

A survey of Arizona and New Mexico ranchers was distributed between September 2024 and March 2025 online via Qualtrics and through hard copies mailed or distributed in person at outreach events. This report only presents the results of Arizona ranchers. The survey was aimed at collecting information from cattle ranchers affected or potentially affected in the future by the presence of Mexican wolves. A total of 95 individuals responded to the survey, of which 89 were ranchers. Of those respondents, 28 reported ranching in Arizona. Arizona respondents reported an average herd size of 385 cows (minimum 10, maximum 1,500, median 235). 26 ranchers provided information on the share of their household income they derive from ranching (Table 7). 8 reported receiving 75% or more of their income from ranching, 9 between 50% and 75%, 3 between 25% and 49%, and 6 reported less than 25% of their income from ranching.

TABLE 7. PERCENT OF RANCHER INCOME FROM RANCHING

Category	Responses
Less than 25%	6
25% to 49%	3
50% to 75%	9
More than 75%	8

Of the 28 Arizona respondents, 24 reported whether or not they had experienced direct or indirect effects of wolves on their herd (Table 8). 9 of 24 respondents reported experiencing depredation or injury and indirect stress impacts. 5 reported indirect stress impacts alone. 9 respondents reported not experiencing wolf impacts on their herds, and one respondent reported not being sure.

TABLE 8. RESPONDENT-REPORTED WOLF IMPACTS

Reported Wolf Impact	Respondents
Yes, directly through depredation or injury and indirectly through stress or other impacts	9
Yes, indirectly through stress or other impacts only	5
I'm not sure	1
No	9

Ranchers who reported experiencing direct effects such as depredation or injury were most concentrated in the MWEPA Zone 1, while those reporting indirect impacts only or no impacts were mostly in Zones 2 or 3 (Table 9).

TABLE 9. REPORTED WOLF IMPACTS BY RANCH LOCATION (MWEPA ZONES)

	Direct & Indirect Impacts	Indirect Impacts Only	No Impacts
Mostly in Zone 1	6	0	0
Mostly in Zone 2	3	4	8
Mostly in Zone 3	0	1	1

Respondents were asked to report their lowest, typical, and highest annual death loss across ranch animals, including cows, bulls, yearlings, calves, horses, and dogs (Table 10). In a typical year, the lowest number of animals depredated was 0 across all categories, while the highest number of cows depredated was 2 cows, 4

yearlings, and 10 calves. In the highest year reported by respondents, the maximum number of depredated animals were 6 cows, 8 yearlings, and 25 calves.

TABLE 10. LOWEST, TYPICAL, & HIGHEST REPORTED ANNUAL DEATH LOSS ACROSS RANCH ANIMALS (MINIMUM, MAXIMUM, AND AVERAGE)

	Animal	Minimum	Maximum	Average
Lowest Annual Death Loss Due to Wolves	Cow	0	1	0.6
	Bull	0	0	0.0
	Yearling	0	1	0.2
	Calf	0	4	3.0
	Horse	0	0	0.0
	Dog	0	0	0.0
Typical Annual Death Loss Due to Wolves	Cow	0	2	0.6
	Bull	0	0	0.0
	Yearling	0	4	0.8
	Calf	0	10	4.0
	Horse	0	0	0.0
	Dog	0	0	0.0
Highest Annual Death Loss Due to Wolves	Cow	0	6	1.6
	Bull	0	0	0.0
	Yearling	0	8	2.0
	Calf	0	25	7.8
	Horse	0	0	0.0
	Dog	0	0	0.0

In addition to questions regarding the impacts of wolf presence on ranching operations, the survey presented questions to better understand rancher attitudes towards wolf presence (Figure 8) and the impacts of wolf presence on respondents' ranching operations (Figure 9). Ranchers generally agree that the success of their ranching operation is tied to ecosystem health. While respondents were split regarding whether or not predators are part of a healthy ecosystem, most respondents agree that the presence of predators and other wildlife on public lands comes as part of operating on public lands. They overwhelmingly agree that too much responsibility for ensuring populations of threatened and endangered species is borne by ranchers and do not support maintaining a healthy wild population of Mexican wolves. Respondents agreed that Mexican wolf depredation is a more serious problem than depredation by other large predators on the landscape, and that Mexican wolf depredation has become a more serious problem over the past 10 years. There was a mixed response on whether the economic impacts they had experienced due to Mexican wolf presence were tolerable, but also strongly agreed that Mexican wolf presence is a threat to the ranching way of life. There was also mixed response as to whether they would be more accepting of Mexican wolf presence if compensation covered the full direct and indirect costs of presence, though more respondents indicated varying levels of agreement than disagreement.

FIGURE 8. SURVEY RESPONSES ON ATTITUDES TOWARDS WOLF PRESENCE

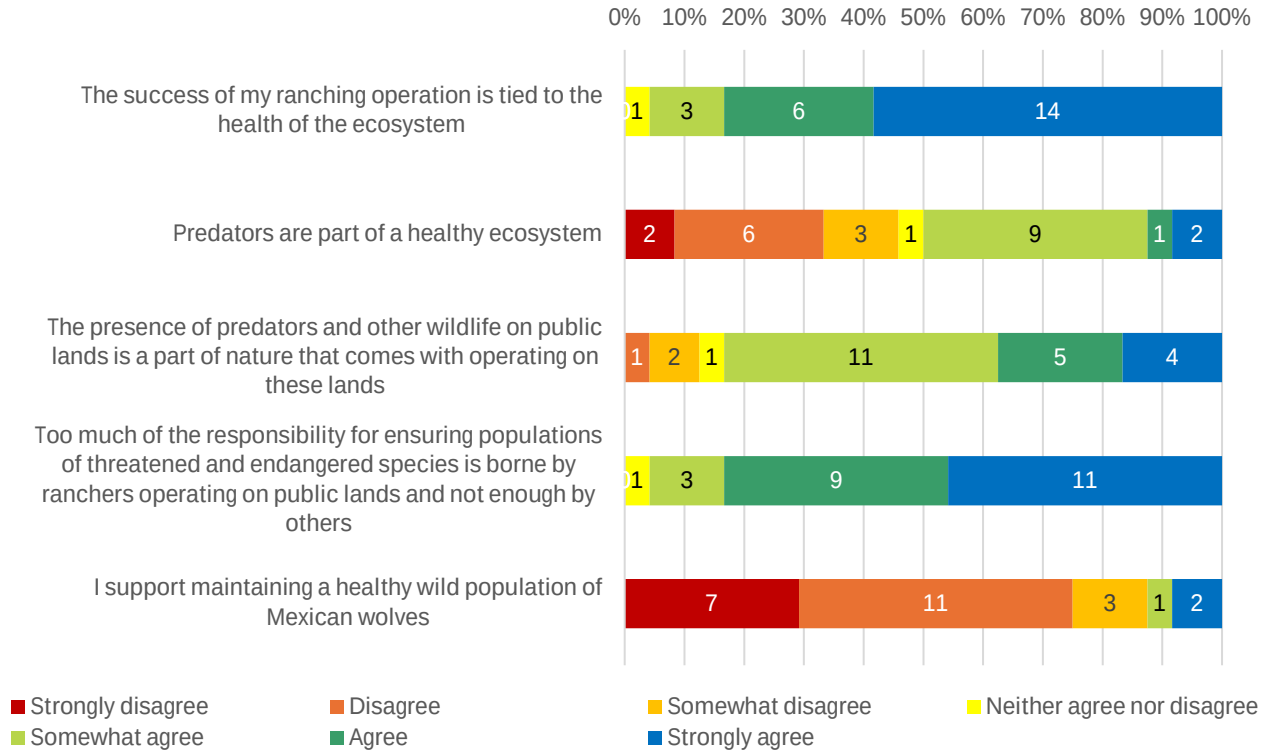
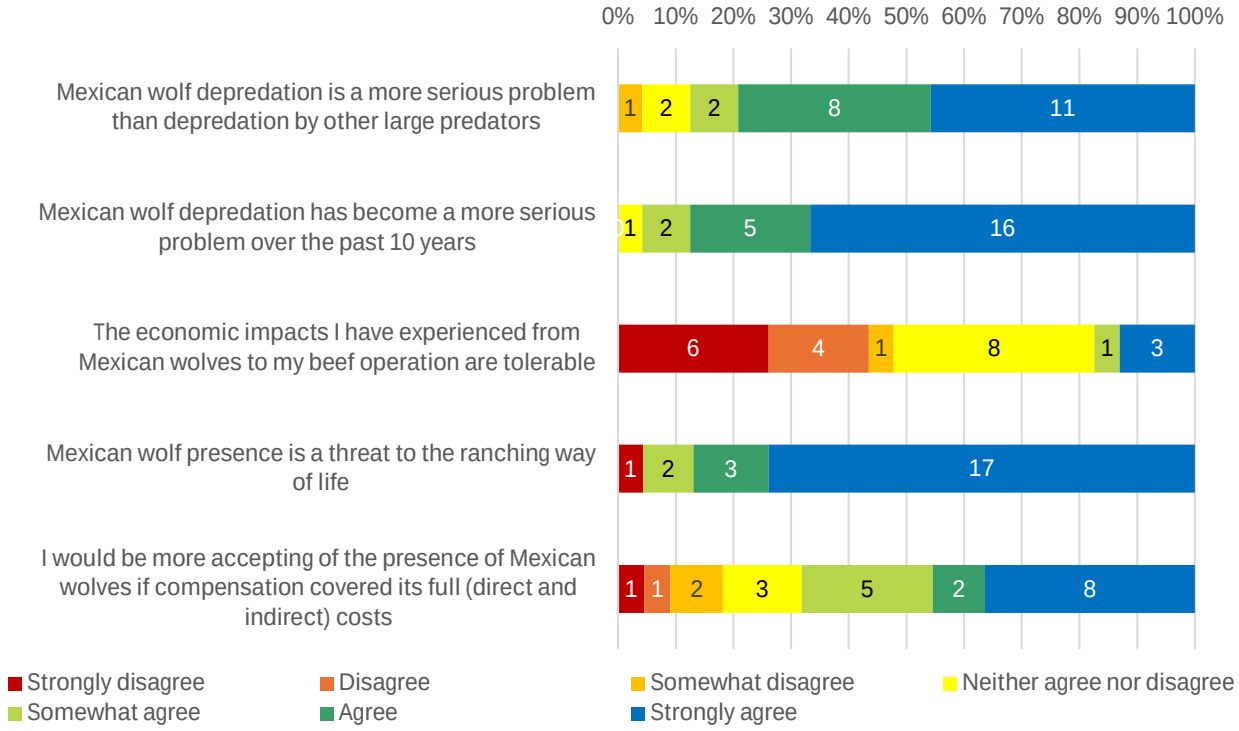
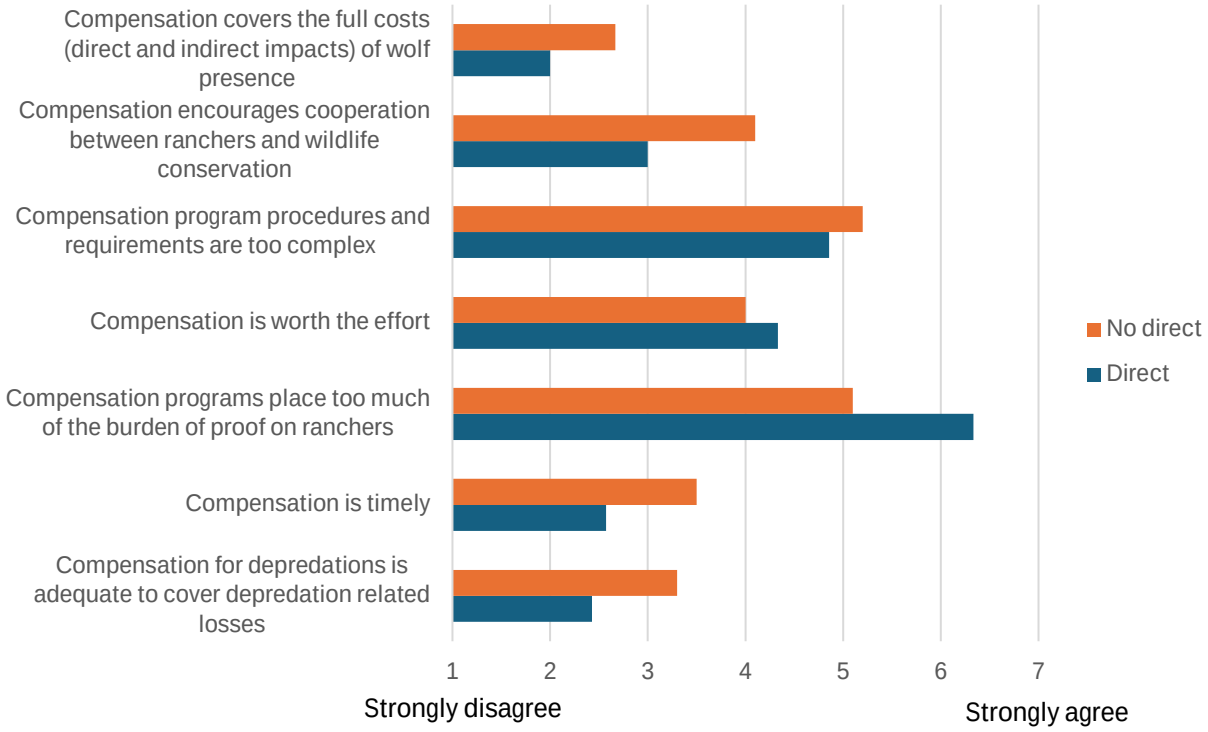


FIGURE 9. SURVEY RESPONSES ON ATTITUDES TOWARDS WOLF EFFECTS



Comparing the responses to these attitudinal questions between ranchers reporting having experienced direct depredations and those who have not, we see that, generally, attitudes are very similar across groups, with some small differences. Regarding whether the economic impacts of wolves on their operations are tolerable, ranchers reporting having experienced direct impacts were in greater disagreement that the impacts are tolerable. They also tended to be in stronger agreement that depredation by Mexican wolves has become a more serious problem over the past 10 years, that it is a threat to the ranching way of life, and that too much responsibility for threatened and endangered species is borne by ranchers operating on public lands (Figure 10).

FIGURE 10. COMPARISON OF ATTITUDINAL RESPONSES BETWEEN RANCHERS EXPERIENCING DIRECT DEPREDATION & THOSE WHO HAVE NOT



Comparing rancher's experiences to others, 2 respondents reported experiencing worse impacts than others in their area. 6 reported impacts similar to those around them, 1 reported less impacts than others around them, and 10 reported not knowing how the impacts they've experienced compared to others around them (Table 11).

TABLE 11. COMPARISON OF OWN RANCH IMPACTS TO OTHER NEARBY RANCHES

Comparative Impact	Responses
My ranch operation has been impacted by wolves **more** than other ranches in my area	2
My ranch operation has been impacted by wolves **about the same** as other ranches in my area	6
My ranch operation has been impacted by wolves **less** than other ranches in my area	1
I'm not sure how the wolf impacts I've experienced compare with other ranches	10

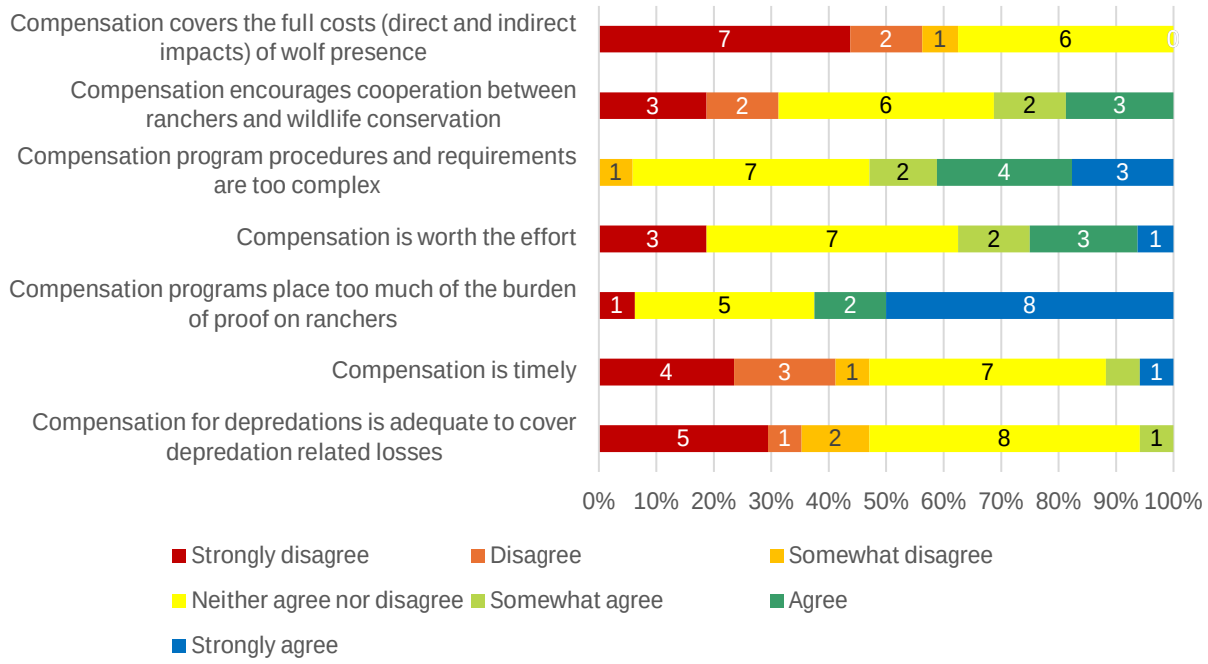
Respondents overwhelmingly report that they expect the impacts of Mexican wolves on their ranch to get worse in the future (Table 12). Expectations of future impacts may drive rancher expenditure on conflict prevention measures or influence decisions around management and investment in the ranch operation.

TABLE 12. RESPONDENT EXPECTATIONS ABOUT FUTURE MEXICAN WOLF IMPACTS

Future Impacts	Responses
The impacts of Mexican gray wolves on my ranch will get **worse** in the future (more impacts)	17
The impacts of Mexican gray wolves on my ranch will **stay the same** in the future	1
The impacts of Mexican gray wolves on my ranch will get **better** in the future (fewer impacts)	0
I do not know	3

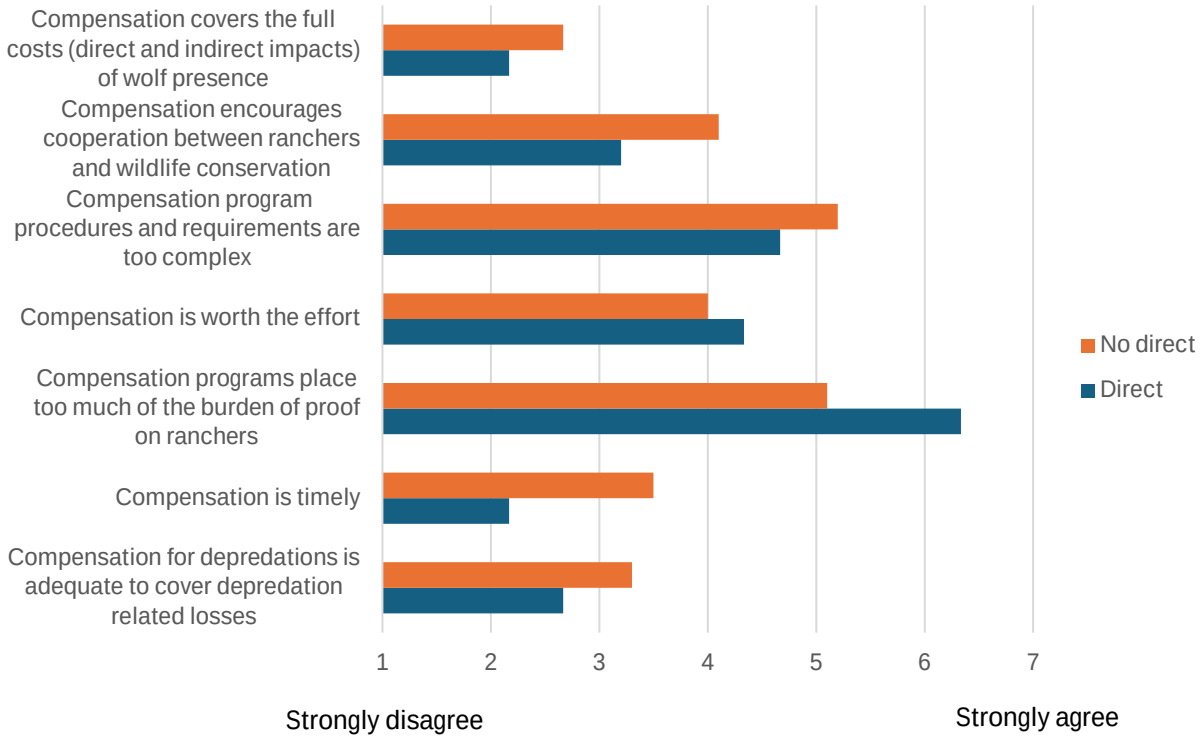
Finally, the survey asked respondents about their experience with and attitudes towards compensation for the impacts of wolves on ranching operations. Figure 11 presents respondents' agreement or disagreement with statements regarding compensation programs. Respondents generally disagreed that compensation programs cover the full costs of wolf impacts, both direct and indirect. There was a mixed response on whether compensation encourages cooperation between ranchers and conservation. Meanwhile, respondents generally agreed that compensation program procedures and requirements are too complex and that they place too much burden of proof on ranchers. Nonetheless, respondents tended to agree that compensation is worth the effort, even though they generally disagreed that compensation is adequate to cover depredation related losses.

FIGURE 11. RESPONDENT ATTITUDES TOWARDS COMPENSATION PROGRAMS



Comparing responses of ranchers reporting having directly experienced depredation and those who have not, ranchers reporting direct depredation generally have stronger opinions towards compensation programs, reporting stronger agreement that compensation programs place too much burden of proof on ranchers and stronger disagreement that compensation covers the full costs of wolf presence, that it encourages cooperation, and that it is timely (Figure 12).

FIGURE 12. COMPARISON OF ATTITUDINAL QUESTIONS ON COMPENSATION BETWEEN RANCHERS REPORTING DIRECT DEPREDATION & THOSE NOT REPORTING DIRECT DEPREDATION



Eight Arizona respondents indicated having filed for compensation in the past, 5 of which received compensation and 3 of which had not. 10 respondents reported never applying for compensation (Table 13). All of the ranchers reporting having applied for compensation also reported experiencing direct depredation, while all respondents reporting not having applied for compensation reported either no direct impacts or no depredations but indirect impacts.

TABLE 13. HAVE YOU RECEIVED COMPENSATION FOR WOLF DEPREDATIONS?

Answer	Responses
Yes, in some cases	5
No, but I have applied for compensation	3
I have not applied for depredation compensation	10

Three respondents provided information on expenditures for preventative measures. Two respondents reported annual expenditures between $5,000 and $13,000, while one reported annual expenditures over $150,000. Considering that compensation for preventative measures is available to producers, it is possible that some of these expenditures may represent spending of funding provided by grants for conflict avoidance and not ranch resources alone. Similarly, three respondents provided information on the number of hours dedicated to preventative measures annually. These ranged between 190 and over 3,800 hours annually.

Representative Ranch Model

The following section of the report presents the results of a representative ranch herd planning model under differing wolf effect scenarios. In the first section, we present an analysis of the effects of both a single calf depredation and a single cow depredation on herd size, observing a multi-year effect of losing a cow. We then present an analysis of short- run annual cash returns under different levels of wolf depredation and stress-induced weight loss across the herd. Finally, we present a long-term analysis of returns over total cost across 30 years, including a projection of future costs and returns. Long-term returns over total costs represent a measure of the ranch's revenue-generating potential as it would be capitalized into ranch property values.

Model Assumptions

As in the 2018 study (Bickel et al., 2018), the representative ranch model assumes the following general cow-calf operation parameters, based on Arizona ranch budgets (Teegerstrom & Tronstad, 2017) and results of the survey conducted for the 2018 study:

- Constant 367-head breeding herd (comprised of 293 bred cows and 74 bred heifers) and an additional 81 yearling heifers, for a total herd size of 448
- 71% live calves of pregnant bred cows, 69% live calves of pregnant bred heifers, and 1% death loss of calves born
- 50/50 heifer/steer calf split[2]
- 1% death loss for bred cows, 1% death loss for bred heifers, and 2% death loss for yearling heifers
- 17% cull rate for bred cows, 28% cull rate for bred heifers, and 6% cull rate for yearling heifers
- Closed herd (no outside purchase of breeding herd)
- Cow to bull ratio: 15
- Bull cull rate: 20%
- Calf crop: 70% (calves weaned/breeding herd)
- Average calf sale weight: 518 pounds
- Cull cow sale weight: 1,023 pounds
- Cull bull sale weight: 1,557 pounds

The representative ranch model was updated for inflation to reflect recent agricultural input and cattle prices. Assumptions of those price updates can be found in Appendix A.

Representative Ranch Model Results

The following model results provide an update to the previous analysis using the same assumptions about possible levels of wolf depredation of cattle and calves, weight loss due to stress, and additional management costs associated with deterring wolves.

Single Depredation Event

We examine the effects of a single depredation on the representative ranch's herd over time. We start with the depredation of a single calf, followed by the depredation of a single cow.

Depredation of a Calf

Table 14 presents the simulated effects of the depredation of a single heifer calf in year 2 (highlighted in orange) on the representative ranch's herd dynamics. The loss of a single calf simply results in one fewer calf to be sold that season (174 instead of 175), and a corresponding one-year decline in revenue ($1,038.99

[2] If the number of total calves to wean is odd, we assume one additional heifer is produced than steers.

assuming an average sales price year). There are no changes to the breeding herd size when a calf is depredated.

TABLE 14. CHANGE IN CALVES SOLD DUE TO WOLF DEPREDATION OF CALF IN YEAR 2

	YR 1	YR 2	YR 3	YR 4	YR 5
Beginning Year Herd Size					
Bred Cows	293	293	293	293	293
Bred Heifers	74	74	74	74	74
Yearling Heifers	81	81	81	81	81
TOTAL BEGINNING HERD SIZE	**448**	**448**	**448**	**448**	**448**
Calf Production					
Total Calves to Wean	256	256	256	256	256
Heifers Available	128	128	128	128	128
Steers Available	128	128	128	128	128
Heifer Calves Needed to Maintain Herd Size	81	81	81	81	81
Heifers Sold	47	**46**	47	47	47
Steers Sold	128	128	128	128	128
TOTAL CALVES SOLD	**175**	**174**	**175**	**175**	**175**
Reductions to Herd Size					
Bred Cow Death Loss	3	3	3	3	3
Bred Cows Culled	50	50	50	50	50
Bred Cows	240	240	240	240	240
Bred Heifer Death Loss	1	1	1	1	1
Bred Heifer Cows Culled	20	20	20	20	20
Bred Heifers	53	53	53	53	53
Heifer Calf Wolf Death Loss	0	1	0	0	0
Ending Year Herd Size					
Old Bred Cows	240	240	240	240	240
New Bred Cows (Bred Heifers to Bred Cows)	53	53	53	53	53
TOTAL BRED COWS	**293**	**293**	**293**	**293**	**293**
Bred Heifers (Yearling Heifers to Bred Heifers)	74	74	74	74	74
TOTAL BRED HEIFERS	**74**	**74**	**74**	**74**	**74**
Heifer Calves Kept for Use as Yearling Heifers in Next Year	81	81	81	81	81
TOTAL YEAR END HERD SIZE	**448**	**448**	**448**	**448**	**448**

Source: Authors' calculations; Teegerstrom and Tronstad (2017), Biological Breeding Herd and Budget Model (no date)

Depredation of a Cow

Whereas the loss of a calf to wolf depredation has a single-year effect on revenue, the loss of a cow has a multi-year effect due to the dual role of cows as productive assets as well as commodities with market value. Table 15 presents the result of the depredation of a single cow on the representative ranch's herd dynamics. The cow depredation occurs in year 2 (highlighted in red), decreasing the number of bred cows from 293 to 292 head. In response to the wolf depredation, the rancher retains a calf that would have otherwise been sold in year 2. This results in 1 less calf being sold in year 2 (174) compared to the previous year (175). The yearling heifers retained in year 1 transition to bred heifers maintaining the number of bred heifers at 74 in year 2. By retaining an additional calf in year 2, there is one additional yearling heifer in the herd the following year, making a total number of 82 yearling heifers. However, the rancher is still missing a bred cow, with only 292 bred cows in year 3. As the yearling heifer is not able to breed yet, there is still a shortage of one bred cow, and the number of calves to wean is 255, one calf fewer than the previous year. Again, the result is 1 fewer calf sold in year 3 (174 instead of 175). At the beginning of year 4, there is still 1 fewer bred cow, but by

retaining 1 calf two years prior, there is now 1 additional bred heifer (75 instead of 74), and the number of calves to wean and number of calves sold normalizes at 255 and 175, respectively. By the end of year 4, the composition of the herd normalizes to its original starting point of 293 bred cows, 74 bred heifers, and 81 yearling heifers.

This simple analysis demonstrates that the lost value resulting from the depredation of a cow is not simply the market value of the cow, but the forgone revenues from calf sales over time. A depredation of a cow disrupts the production cycle, changes the herd composition, and results in a multi-year revenue loss. Like the results in Anderson et al. (2014), this analysis demonstrates that the loss of a cow is equal to the loss of two calves.

TABLE 15. HERD COMPOSITION CHANGES DUE TO WOLF DEPREDATION OF COW IN YEAR 2

	YR 1	YR 2	YR 3	YR 4	YR 5
Beginning Year Herd Size					
Bred Cows	293	293	292	292	293
Bred Heifers	74	74	74	75	74
Yearling Heifers	81	81	82	81	81
TOTAL BEGINNING HERD SIZE	**448**	**448**	**448**	**448**	**448**
Calf Production					
Total Calves to Wean	256	256	255	256	256
Heifers Available	128	128	127	128	128
Steers Available	128	128	128	128	128
Heifer Calves Needed to Maintain Herd Size	81	82	81	81	81
Heifers Sold	47	46	46	47	47
Steers Sold	128	128	128	128	128
TOTAL CALVES SOLD	**175**	**174**	**174**	**175**	**175**
Reductions to Herd Size					
Bred Cow Death Loss	3	3	3	3	3
Bred Cows Culled	50	50	50	50	50
Bred Cow Wolf Loss	0	1	0	0	0
Bred Cows	240	239	239	239	240
Bred Heifer Death Loss	1	1	1	1	1
Bred Heifer Cows Culled	20	20	20	20	20
Bred Heifers	53	53	53	54	53
Ending Year Herd Size					
Old Bred Cows	240	239	239	239	240
New Bred Cows (Bred Heifers to Bred Cows)	53	53	53	54	53
TOTAL BRED COWS	**293**	**292**	**292**	**293**	**293**
Bred Heifers (Yearling Heifers to Bred Heifers)	74	74	75	74	74
TOTAL BRED HEIFERS	**74**	**74**	**75**	**74**	**74**
Heifer Calves Kept for Use as Yearling Heifers in Next Year	81	82	81	81	81
TOTAL YEAR END HERD SIZE	**448**	**448**	**448**	**448**	**448**

Source: Authors' calculations; Teegerstrom and Tronstad (2017), Biological Breeding Herd and Budget Model (no date)

Short Run Annual Cash Returns

Short-run annual cash returns represent the profitability of a ranch operation and its financial viability in the short-run as a commercial cow-calf operation. We model the effects of different levels of calf depredation on short-term ranch returns assuming average cattle prices and input costs (Table 16).

For the representative ranch, the following calf depredation rates and weight loss rates correspond to the following calf losses and sale weights.

TABLE 16. CALF DEPREDATION & WEIGHT LOSS SCENARIO DETAILS

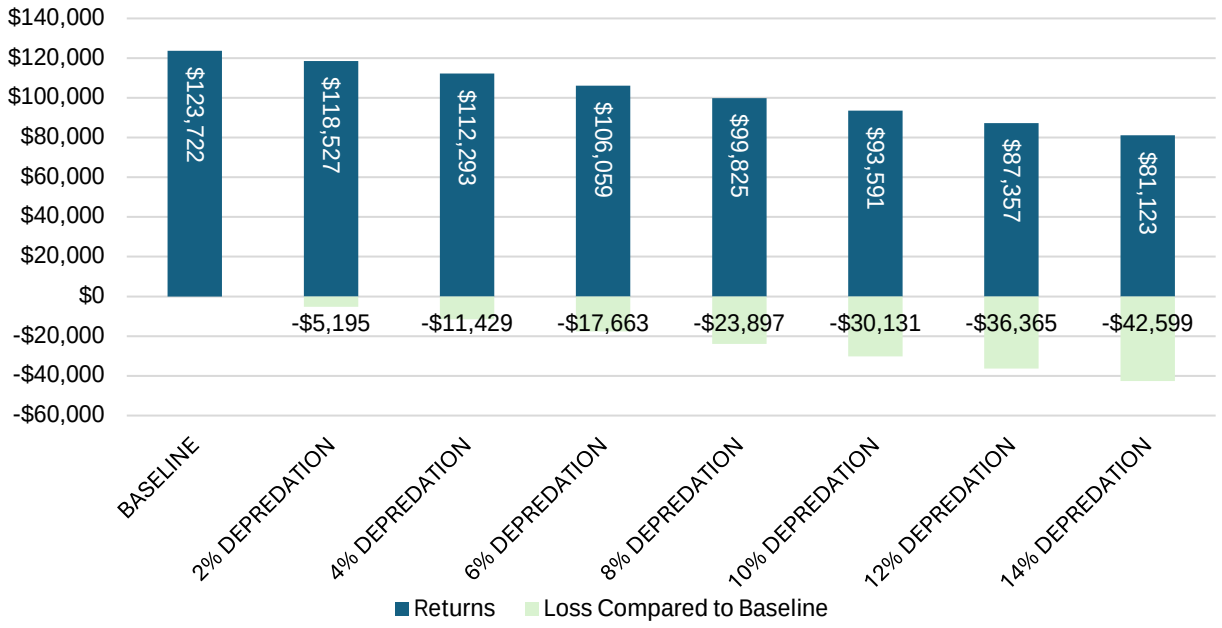
Calf Depredation Rate	Calves Lost
0%	0
2%	5
4%	11
6%	17
8%	23
10%	29
12%	36
14%	41

Calf Weight Loss Rate	Calf Sale Weight
0.0%	518
2.0%	508
3.5%	500
7.0%	482
10.0%	466

Calf Depredation

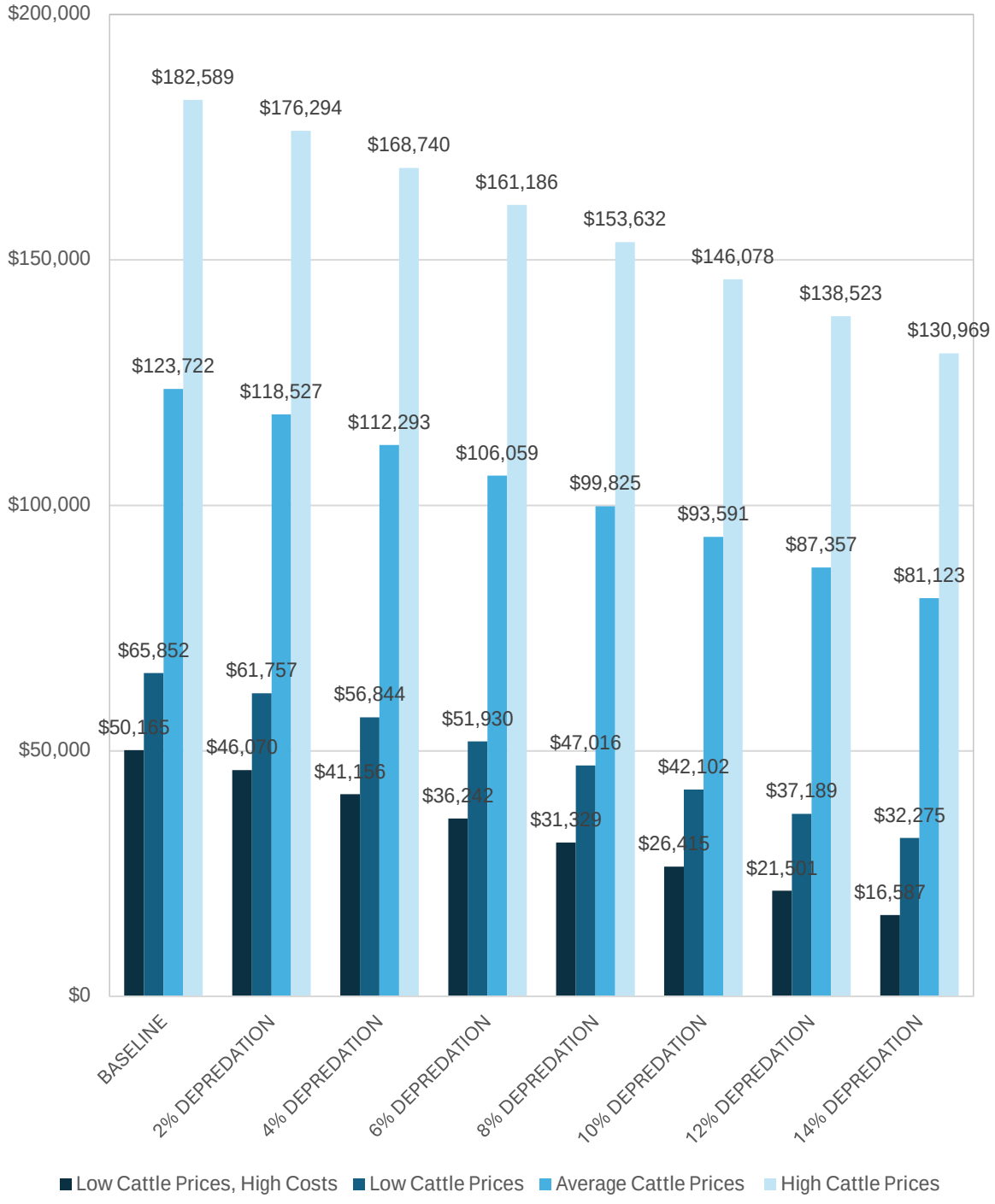
Figure 13 presents estimated ranch returns under increasing calf depredation rates, as well as corresponding losses as compared with a baseline of no calf depredation by wolves. Estimated impacts to ranch cash returns range from -4% at 2% calf depredation to -34% at 14% calf depredation.

FIGURE 13. RANCH CASH RETURNS & LOSSES UNDER CALF DEPREDATION SCENARIOS



We couple these estimated depredation impacts on ranch cash returns with low, average, and high cattle prices, as well as the combined effects of low cattle prices and high costs (Figure 14). A combination of 14% depredation with low cattle prices and high input costs reduces the representative ranch's short-term returns from a baseline of $182,589 to $16,587, assuming the depredations are not compensated.

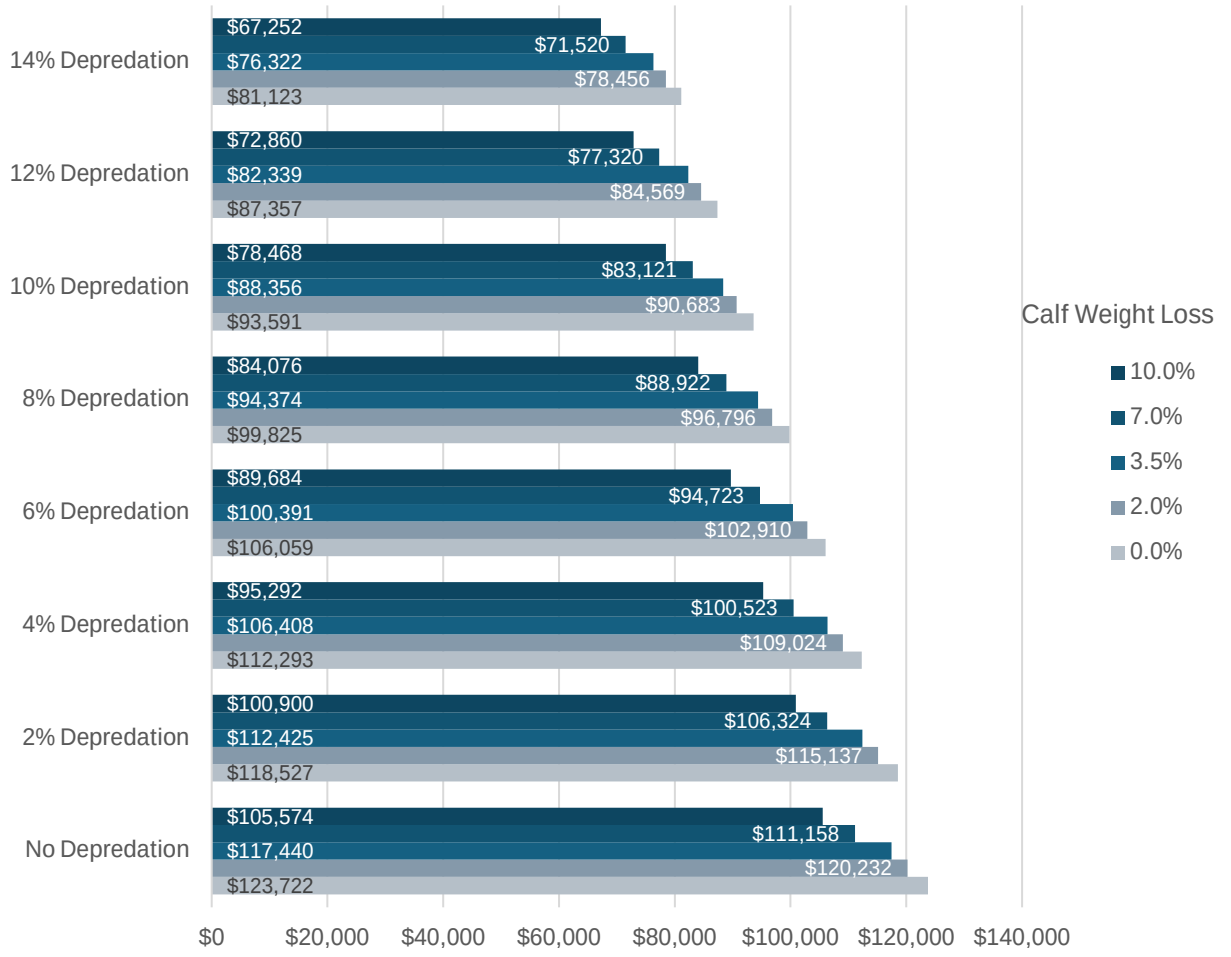
FIGURE 14. ESTIMATED RANCH CASH RETURNS UNDER COMBINED DEPREDATION & PRICE SCENARIOS



Calf Depredation & Weight Loss

Combining calf depredation scenarios with weight loss across all calves, we model the effects on representative ranch returns over cash costs (Figure 15).

FIGURE 15. ESTIMATED RANCH RETURNS UNDER COMBINED DEPREDATION & WEIGHT LOSS SCENARIOS



In terms of the percentage of baseline returns (no wolf effects) achieved under these different weight loss and depredation scenarios, these range from 97% of cash returns achieved under 2% weight loss and no depredation to 54% of returns achieved under 10% weight loss and 14% depredation (Table 17).

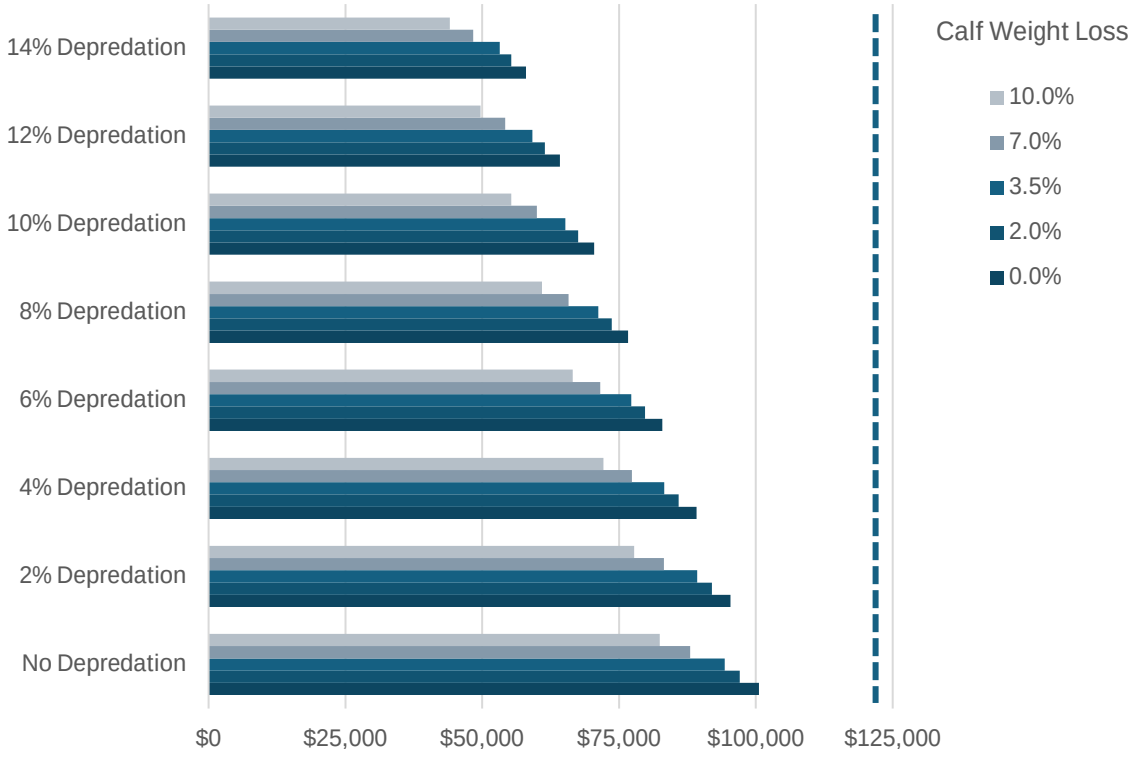
TABLE 17. PERCENTAGE OF BASELINE RETURNS ACHIEVED UNDER COMBINED CALF DEPREDATION & WEIGHT LOSS SCENARIOS

	Calf Depredation							
Weight Loss	***None***	***2%***	***4%***	***6%***	***8%***	***10%***	***12%***	***14%***
0.0%	100%	96%	91%	86%	81%	76%	71%	66%
2.0%	97%	93%	88%	83%	78%	73%	68%	63%
3.5%	95%	91%	86%	81%	76%	71%	67%	62%
7.0%	90%	86%	81%	77%	72%	67%	62%	58%
10.0%	85%	82%	77%	72%	68%	63%	59%	54%

Calf Depredation, Calf Weight Loss, & Additional Management Costs

In addition to the direct and indirect effects of wolf presence on ranch returns, operator investment in conflict avoidance measures represents an additional cost, leading to a decrease in returns, all else held constant. Updated for inflation, ranchers reported an average cost of $79 per cow for conflict avoidance measures such as range riders, fencing, moving cattle, and other practices. Figure 16 presents representative ranch returns under different depredation and weight loss levels, assuming that the ranch invests the average amount per cow in conflict avoidance. The dotted line represents baseline returns for the representative ranch with no depredation, no weight loss, and no spending on conflict avoidance.

FIGURE 16. ESTIMATED RANCH RETURNS UNDER COMBINED DEPREDATION & WEIGHT LOSS SCENARIOS & AVERAGE SPENDING ON CONFLICT AVOIDANCE



Expressed as a percentage of baseline returns (no wolf effects) achieved with different levels of calf depredation, weight loss, and additional management costs of $79 per cow, returns vary from 81% of baseline with additional management costs, but not depredation or weight loss, to 36% of baseline with additional management costs, 10% weight loss, and 14% calf depredation (Table 18).

TABLE 18. PERCENT OF BASELINE RETURNS ACHIEVED UNDER COMBINED CALF DEPREDATION, WEIGHT LOSS, AND ADDITIONAL MANAGEMENT COST SCENARIOS

	---------- Calf Depredation ----------							
Weight Loss	***None***	***2%***	***4%***	***6%***	***8%***	***10%***	***12%***	***14%***
0.0%	81%	77%	72%	67%	62%	57%	52%	47%
2.0%	78%	74%	69%	64%	60%	55%	50%	45%
3.5%	76%	72%	67%	62%	58%	53%	48%	43%
7.0%	71%	67%	63%	58%	53%	48%	44%	39%
10.0%	67%	63%	58%	54%	49%	45%	40%	36%

Long Run Ranch Returns Over Time

Finally, we use the same budget model to examine the potential long-term, multi-year impacts of wolf presence on ranch returns. This analysis considers two aspects of potential multi-year impacts: (1) the variation in annual net returns from year-to-year and (2) the possible changes in the value of the ranch through reductions in the cumulative net present value of ranch returns over a 30-year period.

Potential long-term impacts are first analyzed by estimating annual ranch returns over 30 years from 1998 to 2027. 1998 is the year that wolves were first reintroduced into Arizona. Representative ranch revenues are estimated using a historic price series from 1998 to 2016 (CattleFax and the Livestock Marketing Information Center (LMIC)) from Bickel et al., 2018, cow-calf operation costs and returns from 2017 to 2023 (USDA AMS) and two projected price series for 2024 to 2027 (USDA AMS and FAPRI). Whereas the previous section focused on the short-term impacts on the representative ranch's annual cash returns, this section incorporates fixed costs, or the ownership costs of the operation. Costs are estimated based on Teegerstrom & Tronstad (2017) and previous cost and return estimates for Arizona (Teegerstrom and Tronstad, 2000). Both budgets provide high and low estimates for variable costs, ownership (fixed) costs, and the total costs per cow. Using the reported high and low estimates of costs per cow, we estimate the average costs per cow for the years 2000 and 2016. Using these two values as fixed, we estimate the costs per cow from 1998 to 2016, assuming the costs of production increase by 2% every year. From 2016 to 2022, estimated costs are adjusted annually using USDA Costs & Returns cost estimates indexed to 2016. For projections from 2022 to 2027, projected costs are based on USDA AMS projections and ranch revenues are based on an average of USDA AMS and FAPRI projections, both indexed to 2022 values.

While ranch property values depend on many factors, revenue-generating potential only being one among many, this analysis relies on economic theory to provide insights into how long-term returns to ranching (and losses from wolves) would be capitalized into the value of a ranch. The productive value of agricultural land can be expressed as the discounted net present value (NPV) of the flow of returns that land would provide over the long term (Burt, 1986). The baseline value of the land, V^0, depends on a discounted flow of net returns over time, in this case from year 1 to year *T,* the end of the planning or investment horizon (Equation 1):

EQUATION 1

$$V^0 = \sum_{t=1}^{T} \frac{R_t}{(1+r)^t}$$

where R_t are net returns to the land in year t, r is the real (constant) discount rate. Previous studies have examined how changes in returns (such as changes in commodity program benefits) to an agricultural operation would become capitalized into farmland values (e.g. Taylor and Brester, 2005). The change we wish to consider is how the direct and indirect costs of wolf depredation are capitalized into ranch values. Wolf depredation causes direct and indirect economic losses of l_t in year t. Returns to ranching absent depredation, R_t, and depredation losses, l_t, may vary from year to year, so that the long-run discounted sum of returns are lower, in other words $V^w < V$, where:

EQUATION 2

$$V^w = \sum_{t=1}^{T} \frac{R_t - l_t}{(1+r)^t}$$

Over the long-run, for example the term of a 30-year mortgage, the value of the ranching operation would be reduced by *L*, where:

EQUATION 3

$$(V^0 - V^W) = \sum_{t=1}^{30} \frac{l_t}{(1+r)^t}$$

The value of a ranch, however, is not based solely on the money-making potential of the land, but also the value placed on the homestead itself and the benefits of the ranching lifestyle itself. Call these other benefits b_t. The presence of wolves can also reduce these "lifestyle" benefits of ranching. Call these losses in lifestyle benefits w_t. If we assume that these lifestyle benefits and losses can be converted into dollar value equivalents, then the ranch value equation becomes:

EQUATION 4

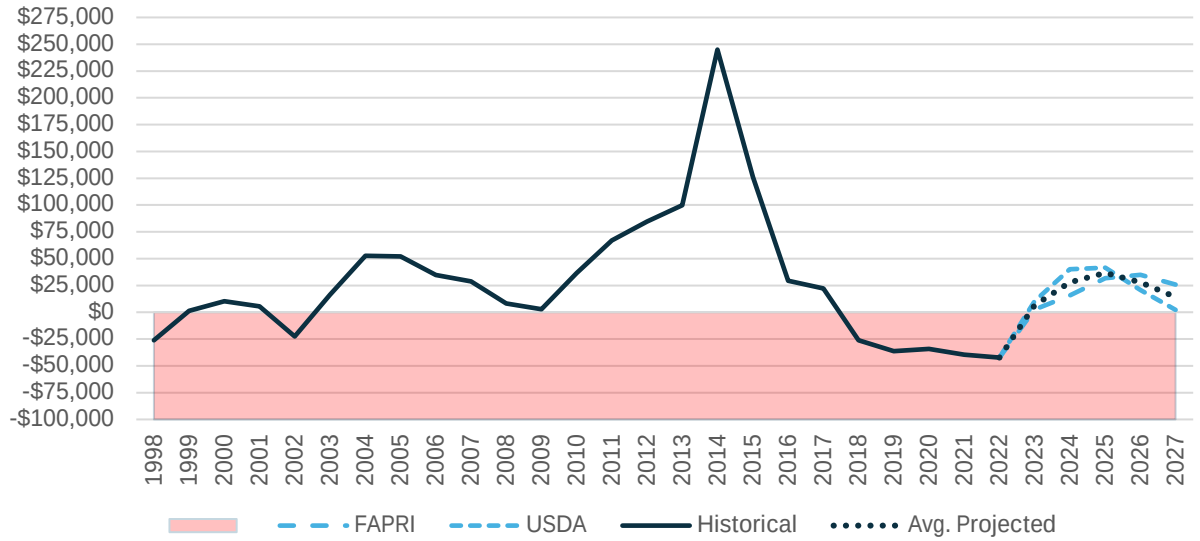
$$V^w = \sum_{t=1}^{T} \frac{(R_t + b_t) - (l_t + w_t)}{(1+r)^t}$$

Wolf depredation can lower the sales prices received for ranches in two ways. First, by reducing annual returns to ranching, through l_t. Second, depredations or wolf presence may lower the willingness to pay of potential buyers, through effects on the ranching lifestyle, w_t. In advance, it is uncertain whether buyers know about wolf presence before a sale and whether their losses are smaller, similar to, or larger than those (w_t) of sellers. While we acknowledge that while losses embodied in w_t are real economic losses, these are more difficult to measure and subjective.

With that established, this analysis considers the lost productive value of a representative ranch, captured in Equation 3 as the NPV of estimated wolf-related losses over a 30-year period. We use a historical price series from the 2018 analysis from 1998 to 2016 based on CattleFax and LMIC price series data (Bickel et al., 2018). From 2016 to 2022, returns are calculated using receipts and expenses indexed to 2016 levels from the USDA Costs and Returns for cow/calf operations in the Basin and Range region (USDA, 2024). The projected prices for 2023 onward represent an average of FAPRI and USDA projected receipts, indexed to 2022, and FAPRI expense projections, indexed to 2022. Details of budget model updates are available in Appendix A.

Figure 15 presents estimated baseline returns for the representative ranch from 1998, the year wolves were reintroduced into the Blue Range Wolf Recovery Area, to 2027. The baseline assumes no wolf effects, direct or indirect.

FIGURE 17. PROJECTED ANNUAL RETURNS OVER TOTAL COSTS FOR REPRESENTATIVE RANCH, 1998-2027 – BASELINE, NO WOLF EFFECTS (2024 USD)



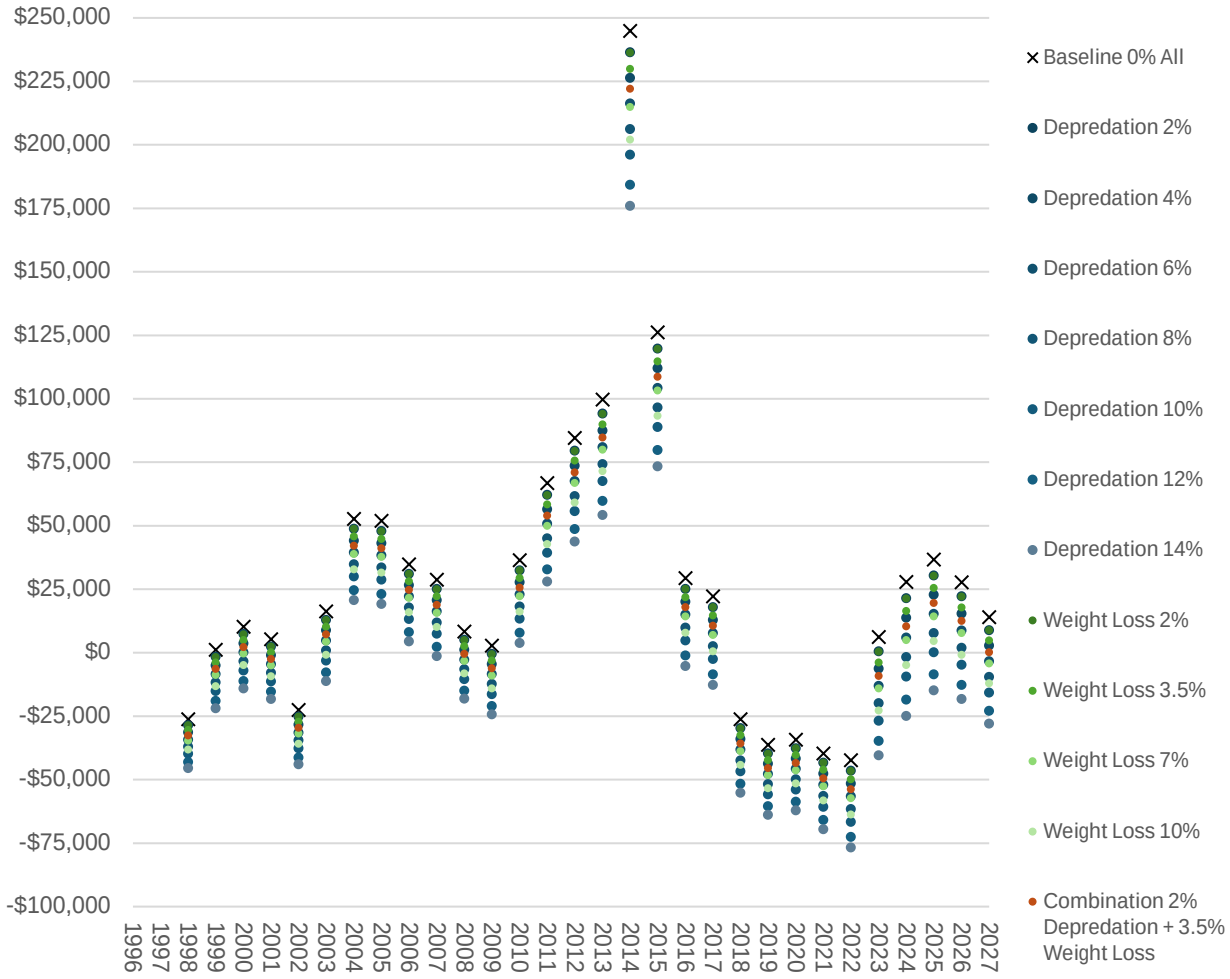
Using this baseline as a comparison, Table 20 presents estimated ranch returns under varying wolf effect scenarios: calf depredation ranging from 2% to 14%, calf weight loss ranging from 2% to 10%, and a combination of 2% calf depredation with 3.5% calf weight loss, representing average reported wolf effects from Bickel et al. (2018) based on survey data and published literature on cattle weight loss associated with wolf-related stress (Ramler et al., 2014). In the baseline scenario of no wolf effects, ranch returns are negative in 7 of 30 years. Under 2% depredation alone, this increases to 9 of 30 years with negative returns over total costs. In the combined 2% calf depredation and 3.5% weight loss scenario, returns are negative in 12 of 30 years, demonstrating the financial strain that wolf presence can create for the representative ranch.

TABLE 19. ESTIMATED REPRESENTATIVE RANCH RETURNS UNDER VARYING WOLF EFFECT SCENARIOS (2024 USD), 1998-2027

	Baseline	Depredation							Weight Loss				Combined
	0% All	*2%*	*4%*	*6%*	*8%*	*10%*	*12%*	*14%*	*2%*	*3.5%*	*7%*	*10%*	*2% Dep. + 3.5% WL*
1998	-$26,204	-$28,548	-$31,362	-$34,175	-$36,989	-$39,802	-$43,085	-$45,429	-$28,595	-$30,389	-$34,574	-$38,161	-$32,569
1999	$1,200	-$1,608	-$4,978	-$8,348	-$11,718	-$15,088	-$19,019	-$21,827	-$1,665	-$3,813	-$8,825	-$13,122	-$6,424
2000	$10,300	$7,324	$3,753	$181	-$3,390	-$6,962	-$11,128	-$14,104	$7,265	$4,988	-$325	-$4,878	$2,220
2001	$5,348	$2,469	-$986	-$4,441	-$7,896	-$11,351	-$15,382	-$18,261	$2,411	$209	-$4,931	-$9,336	-$2,469
2002	-$22,499	-$25,116	-$28,256	-$31,396	-$34,536	-$37,676	-$41,340	-$43,956	-$25,168	-$27,170	-$31,841	-$35,844	-$29,603
2003	$16,260	$12,916	$8,902	$4,888	$875	-$3,139	-$7,821	-$11,166	$12,849	$10,290	$4,320	-$798	$7,179
2004	$52,761	$48,852	$44,162	$39,472	$34,782	$30,092	$24,620	$20,711	$48,774	$45,784	$38,808	$32,827	$42,149
2005	$51,942	$47,946	$43,150	$38,354	$33,558	$28,763	$23,168	$19,171	$47,866	$44,808	$37,675	$31,560	$41,092
2006	$34,793	$31,095	$26,657	$22,219	$17,781	$13,343	$8,165	$4,467	$31,021	$28,192	$21,590	$15,932	$24,752
2007	$28,775	$25,110	$20,711	$16,312	$11,913	$7,514	$2,382	-$1,283	$25,036	$22,232	$15,689	$10,080	$18,823
2008	$8,314	$5,087	$1,215	-$2,658	-$6,530	-$10,402	-$14,920	-$18,146	$5,022	$2,554	-$3,206	-$8,143	-$447
2009	$2,814	-$484	-$4,443	-$8,401	-$12,359	-$16,317	-$20,935	-$24,233	-$550	-$3,074	-$8,961	-$14,008	-$6,141
2010	$36,475	$32,498	$27,725	$22,953	$18,181	$13,409	$7,841	$3,864	$32,418	$29,376	$22,277	$16,192	$25,677
2011	$66,893	$62,154	$56,468	$50,781	$45,095	$39,409	$32,774	$28,036	$62,059	$58,434	$49,976	$42,726	$54,027
2012	$84,573	$79,595	$73,621	$67,647	$61,673	$55,699	$48,729	$43,751	$79,495	$75,687	$66,801	$59,184	$71,057
2013	$99,756	$94,210	$87,554	$80,899	$74,244	$67,589	$59,824	$54,278	$94,099	$89,856	$79,956	$71,471	$84,698
2014	$244,955	$236,537	$226,435	$216,332	$206,230	$196,128	$184,342	$175,924	$236,369	$229,928	$214,901	$202,021	$222,099
2015	$126,207	$119,768	$112,041	$104,313	$96,586	$88,859	$79,844	$73,405	$119,639	$114,713	$103,219	$93,367	$108,724
2016	$29,418	$25,184	$20,103	$15,021	$9,940	$4,859	-$1,069	-$5,303	$25,099	$21,860	$14,301	$7,823	$17,922
2017	$22,260	$17,993	$12,871	$7,750	$2,628	-$2,493	-$8,468	-$12,736	$17,907	$14,642	$7,024	$494	$10,673
2018	-$26,156	-$29,697	-$33,946	-$38,196	-$42,445	-$46,695	-$51,653	-$55,194	-$29,768	-$32,477	-$38,798	-$44,216	-$35,770
2019	-$36,297	-$39,651	-$43,674	-$47,698	-$51,722	-$55,746	-$60,441	-$63,794	-$39,718	-$42,283	-$48,268	-$53,399	-$45,401
2020	-$34,174	-$37,573	-$41,653	-$45,733	-$49,813	-$53,893	-$58,653	-$62,053	-$37,641	-$40,242	-$46,311	-$51,513	-$43,404
2021	-$39,619	-$43,261	-$47,632	-$52,002	-$56,373	-$60,743	-$65,842	-$69,484	-$43,334	-$46,120	-$52,621	-$58,194	-$49,507
2022	-$42,307	-$46,506	-$51,545	-$56,584	-$61,624	-$66,663	-$72,542	-$76,741	-$46,590	-$49,802	-$57,298	-$63,723	-$53,708
2023	$6,237	$553	-$6,268	-$13,089	-$19,910	-$26,731	-$34,689	-$40,373	$439	-$3,909	-$14,055	-$22,752	-$9,195
2024	$27,918	$21,480	$13,755	$6,029	-$1,696	-$9,422	-$18,435	-$24,873	$21,351	$16,426	$4,935	-$4,915	$10,439
2025	$36,692	$30,407	$22,866	$15,324	$7,782	$241	-$8,558	-$14,843	$30,282	$25,474	$14,256	$4,640	$19,629
2026	$27,841	$22,216	$15,466	$8,716	$1,967	-$4,783	-$12,658	-$18,282	$22,103	$17,801	$7,760	-$846	$12,569
2027	$14,049	$8,925	$2,776	-$3,373	-$9,522	-$15,671	-$22,845	-$27,969	$8,822	$4,902	-$4,245	-$12,084	$137

Presented graphically, it's visible that the value of losses in an individual year will vary in magnitude depending on cattle prices – with higher prices, the revenue lost due to wolf depredation, all else held constant, is larger than in low-price years (Figure 16). Nonetheless, when cattle prices are low, wolf-related losses are more likely to force the representative ranch into negative returns over total costs. More years with negative returns over total cost may threaten the financial viability of a ranch in terms of its value as a profit-generating commercial operation.

FIGURE 18. ESTIMATED REPRESENTATIVE RANCH RETURNS UNDER VARYING WOLF EFFECT SCENARIOS, 1998-2033



Cumulative NPV of Ranch Returns Over Time

Using a 3.9% discount rate (based on average returns to ranching in Arizona from Teegerstrom & Tronstad, 2017), we present the following estimated cumulative net present value (NPV) of returns for the representative ranch under a series of wolf effects. Compared to a baseline of no wolf depredation and no stress-related weight loss, the NPV is modeled to decline by $191,000 over 30 years in the "average" 2% calf depredation and 3.5% calf weight loss scenario. Smaller and larger declines are estimated in other scenarios (Figure 19).

FIGURE 19. ESTIMATED CUMULATIVE NET PRESENT VALUE OF RETURNS AT 30 YEARS GIVEN VARIOUS WOLF EFFECTS (2024 USD)

This calculation of NPV of revenue losses for the representative ranch provides an estimate of how the ranch's productive potential, as capitalized into its value, might change due to wolf effects. It is important to emphasize that this is not the full value of the ranch but rather the estimated productive value of the ranch. Ranches have various other characteristics that contribute to their value. In particular, Torell et al. (2005) found that high value is assigned to ranches in the mountains and close to recreational opportunities and that "a relatively small percentage of ranch value was explained by income earnings" (Torell et al., 2005, p. 537). The value of an individual ranch is explained largely by factors other than the income they can generate through ranching. These factors might include location, elevation, terrain, and whether the ranch has a scenic view. Given this, it is unclear how the presence of wolves may affect, if at all, ranch values in areas impacted by wolves.

Analysis of Compensation Programs

The final section of this analysis considers current compensation programs and their ability to offset losses sustained by ranchers due to the presence of wolves. We begin by presenting average compensation amounts by ALLB per confirmed depredation, and then compare those amounts to the estimated value of loss under different scenarios. Arizona Livestock Loss Board compensation payments are estimated using formulas based on weekly comprehensive boxed beef cutout prices from the USDA Agricultural Marketing Service. These are presented earlier in the report. Because the price changes on a weekly basis, the value of compensation changes over time. Based on reported compensation by the Arizona Livestock Loss Board, the following are annual average compensation amounts per confirmed depredation from 2016 to 2024 for Arizona producers (Table 21).

TABLE 20. ESTIMATED AVERAGE COMPENSATION PER ANIMAL BY ARIZONA LIVESTOCK LOSS BOARD, 2016-2024

	2016	2017	2018	2019	2020	2021	2022	2023	2024
Calf	$1,401	$1,498	$1,440	$1,647	$2,095	$2,092	$2,036	$2,234*	$2,229*
Cow	N/A	$1,556	$1,723	$1,834	$2,182	$2,304	$2,402	$2,439*	$2,664*
Avg.	$1,401	$1,525	$1,487	$1,712	$2,123	$2,186	$2,132	N/A	N/A

Source: Arizona Livestock Loss Board; Author calculations; * Estimated based on formulas

Ranchers reported an average calf weight of 525 pounds at sale, roughly equivalent to the 518-pound average reported in the previous survey (Bickel, et al., 2018). Drawing from cattle prices reported in Table 17, a 518-pound calf would have the following estimated market values (Table 22). As established in the first part of the representative ranch analysis, the financial impact of the loss of a single calf is simply the loss of the revenue from the single calf. Meanwhile, the loss of a single cow corresponds to the loss of two calves that otherwise would have been born had it not been for the loss of the cow. Therefore, we present the revenue impact of the loss of a single cow in Table 22 as well.

TABLE 21. ESTIMATED REVENUE IMPACTS OF LOSS OF SINGLE CALF & COW, 2020-2024

	2020	2021	2022	2023	2024
Calf loss	$821	$870	$891	$1,153	$1,336
Cow loss	$1,642	$1,740	$1,782	$2,305	$2,673

Generally, average compensation rates by the Arizona Livestock Loss Board (ALLB) have been sufficient to cover lost revenues due to direct depredation. Applying for compensation, however, has transaction costs, including the amount of time that ranchers must spend to locate the depredated animal, if possible; complete necessary paperwork; travel; and any other associated activities. We estimate the value of time spent filing for compensation as part of the loss. On average, ranchers reported spending 9 hours filing for compensation (n=3). This is consistent with the times examined in the previous study (Bickel et al., 2018), 6 hours and 10 hours of rancher time, as generally reported by the previous survey respondents. We assume an average hourly wage rate for front-line agricultural supervisors in Arizona by year and estimate a 2024 wage rate using the average wage increase between 2020 and 2023 (Bureau of Labor Statistics, 2024). Assuming a sale weight of 518 pounds and average calf prices as reported in Table 17, estimated losses including rancher time are higher than the revenue impacts above. Estimated losses including time to file for compensation are presented in Table 23.

TABLE 22. ESTIMATED REVENUE LOSS PLUS VALUE OF TIME TO FILE FOR COMPENSATION

Time Filing		2020	2021	2022	2023	2024
6 hours	Calf loss	$986	$1,037	$1,074	$1,344	$1,538
	Cow loss	$1,807	$1,907	$1,965	$2,497	$2,875
10 hours	Calf loss	$1,096	$1,148	$1,196	$1,472	$1,673
	Cow loss	$1,917	$2,018	$2,087	$2,625	$3,009

When time spent filing for compensation is included, in some cases, average compensation per animal by ALLB may be insufficient to cover total losses, including the cost of time to file for compensation (Table 24). This is particularly the case for the loss of a cow in recent years. These calculations assume an average price received by year for a 518-pound calf and a cow depredated at reproductive age, implying a loss of future calves born.

TABLE 23. DIFFERENCE BETWEEN AVERAGE COMPENSATION AMOUNT & TOTAL DEPREDATION COSTS INCLUDING TIME FILING FOR COMPENSATION

Time Filing		2020	2021	2022	2023	2024
6 hours	Calf loss	$1,109	$1,055	$962	$890	$691
	Cow loss	$375	$397	$437	($58)	($211)
10 hours	Calf loss	$999	$944	$840	$762	$556
	Cow loss	$265	$286	$315	($186)	($345)

Finally, we model the adequacy of compensation to cover "average" wolf effects on the representative ranch, which equates to the loss of 5 calves in 5 separate incidents and 3.5% weight loss across all calves. The analysis assumes that the rancher spends 6 or 10 hours applying for compensation for each separate depredation incident, and that weight loss and time spent filing for compensation go uncompensated. Table 25 presents the results of this analysis.

TABLE 24. UNCOMPENSATED LOSS FOR 5 SEPARATE CALF DEPREDATION INCIDENTS & 3.5% CALF WEIGHT LOSS PLUS TIME SPENT FILING FOR COMPENSATION

	2020	2021	2022	2023	2024
6 hours per depredation	$342	($344)	($2,230)	($5,349)	($7,487)
10 hours per depredation	($209)	($900)	($2,840)	($5,989)	($8,159)

The difference in compensation rates and estimated value of loss over time has increased in recent years due to differences in cattle prices and the price of boxed beef. While prices have tracked in a positive direction in both cases, calf prices have increased more than boxed beef prices, leading to the discrepancy.

It is important to mention that all of these results are contingent upon a detected wolf depredation being confirmed by relevant authorities. If a true wolf depredation cannot be confirmed due to decay or scavenging of the carcass, loss of the carcass, or other obstacles to confirmation, that depredation goes fully uncompensated.

Analysis of County-Level Livestock Performance

This section presents the results of an analysis of county-level livestock performance indicators to explore if there are any correlations between wolf presence and regional livestock production levels. Any correlations between wolf presence and declines in livestock production do not necessarily imply causality; as many variables affect regional livestock production. Nonetheless, the presence of correlations between wolf presence and negative trends in livestock production highlights an opportunity for further investigation to explore possible regional-level impacts of wolf presence. Table 25 reports the share of total Gross Domestic Product (GDP) made up of agriculture, forestry, fishing, and hunting in selected Arizona and New Mexico counties, along with state-level and national percentages. Data come from the Bureau of Economic Analysis correspond to the year 2023, and are the most disaggregated figures that include agriculture.

TABLE 25. AGRICULTURE, FORESTRY, FISHING, AND HUNTING AS A PERCENTAGE OF REGIONAL GDP, 2023

Region	Percentage of Regional GDP
Catron, NM	18.2%
Hidalgo, NM	16.1%
Socorro, NM	7.9%
Sierra, NM	7.5%
Grant, NM	2.5%
Cibola, NM	2.1%
New Mexico	1.4%
United States	1.0%
Navajo, AZ	0.9%
Greenlee, AZ	0.7%
Graham, AZ	0.7%
Gila, AZ	0.6%
Arizona	0.5%
Coconino, AZ	0.5%
McKinley, NM	0.3%
Apache, AZ	0.1%
Yavapai, AZ	0.1%

Source: Bureau of Economic Analysis – U.S. Department of Commerce

Nationally, agriculture and other biological resource-related activities account for 1% of US GDP. This percentage is higher in New Mexico (1.4%) and lower in Arizona (0.5%). Even in the rural Arizona counties, agricultural and related activities make up a small share of the economies of these counties (Table 25). For four New Mexico counties (Catron, Hidalgo, Socorro, and Sierra), however, shares are higher. For Catron and Hidalgo, shares are 18% and 16%, respectively. This suggests that the economies of these two counties would be relatively more sensitive to disruptions in agricultural activity.

Table 26 shows patterns of net cash income from farming in selected Arizona and New Mexico Counties. This includes the percentage of operations that had net income gains (positive income from farming) and net income losses (negative income from farming). It also reports average gains per operation for farms with gains and average losses per operation for farms with losses.

TABLE 26. NET CASH INCOME GAINS PER OPERATION IN SELECTED ARIZONA AND NEW MEXICO COUNTIES, 2022

	Percentage of operations with gains	Average gains per operation	Percentage of operations with losses	Average losses per operation
Arizona				
Apache	7%	$17,457	93%	($9,145)
Coconino	17%	$22,195	83%	($13,726)
Gila	19%	$58,514	81%	($28,175)
Graham	29%	$167,885	71%	($18,237)
Greenlee	31%	$24,476	69%	($21,800)
Navajo	12%	$13,215	88%	($10,717)
Yavapai	22%	$46,407	78%	($37,929)
New Mexico				
Catron	35%	$56,465	65%	($25,094)
Cibola	22%	$42,526	78%	($12,013)
Grant	27%	$62,052	73%	($16,433)
Hidalgo	41%	$107,348	59%	($34,809)
McKinley	16%	$8,600	84%	($8,699)
Sierra	34%	$91,531	66%	($33,453)
Socorro	33%	$175,145	67%	($24,159)

Source: 2022 Census of Agriculture

Table 26 illustrates that the majority of farms have net cash income losses from farming. Data reported here are from the most recent, 2022 Census of Agriculture, but this pattern holds for earlier survey years. This suggests that for most farm households, farming is not the main source of household income, or even a positive source of income. Even among operations with net gains, average gains per operation are quite modest for many counties. Counties with relatively higher gains per operation (Graham, Hidalgo, Socorro, and Sierra) have more crop operations than livestock operations (USDA, 2024).

TABLE 27. DISTRIBUTION OF CATTLE AND CALVES SALES FOR SELECTED COUNTIES IN ARIZONA, 2022

	1 to 9 head	10 to 99 head	100 or more head
Apache			
Percent of ranches	71%	26%	2%
Number of ranches			18
Percent of sales	14%	28%	58%
Greenlee			
Percent of ranches	52%	32%	16%
Number of ranches			7
Percent of sales*	7%	32%-35%	58%-61%
Navajo			
Percent of ranches	75%	22%	4%
Number of ranches			17
Percent of sales*	17% or less	31% or less	52% or more
Graham			
Percent of ranches	47%	36%	17%
Number of ranches			23
Percent of sales	3%	22%	75%
Gila			
Percent of ranches	26%	51%	23%
Number of ranches			17
Percent of sales	2%	22%	76%
Coconino			
Percent of ranches	73%	22%	4%
Number of ranches			23
Percent of sales	6%	12%	82%
Yavapai			
Percent of ranches	28%	45%	27%
Number of ranches			50
Percent of sales	1%	16%	83%

Source: 2022 Census of Agriculture * Because of USDA disclosure restrictions, more exact estimates are not available.

Table 27 shows the distribution of ranch sizes and cattle and calves sales for Arizona in 2022. A small share of total ranches in each county had sales of 100 head or more. However, these larger operations accounted for the majority of sales in each county. In Apache and Greenlee Counties, most ranches sold fewer than 10 heads.

Table 28 shows the same data for selected New Mexico counties. Similarly to Arizona, most sold less than 100 heads, while ranches with more than 100 head of sales account for the majority of total sales. The share of ranches with more than 100 head in sales is somewhat higher in some New Mexico counties (e.g., Catron, Hidalgo, and McKinley Counties).

TABLE 28. DISTRIBUTION OF CATTLE AND CALVES SALES FOR SELECTED COUNTIES IN NEW MEXICO, 2022

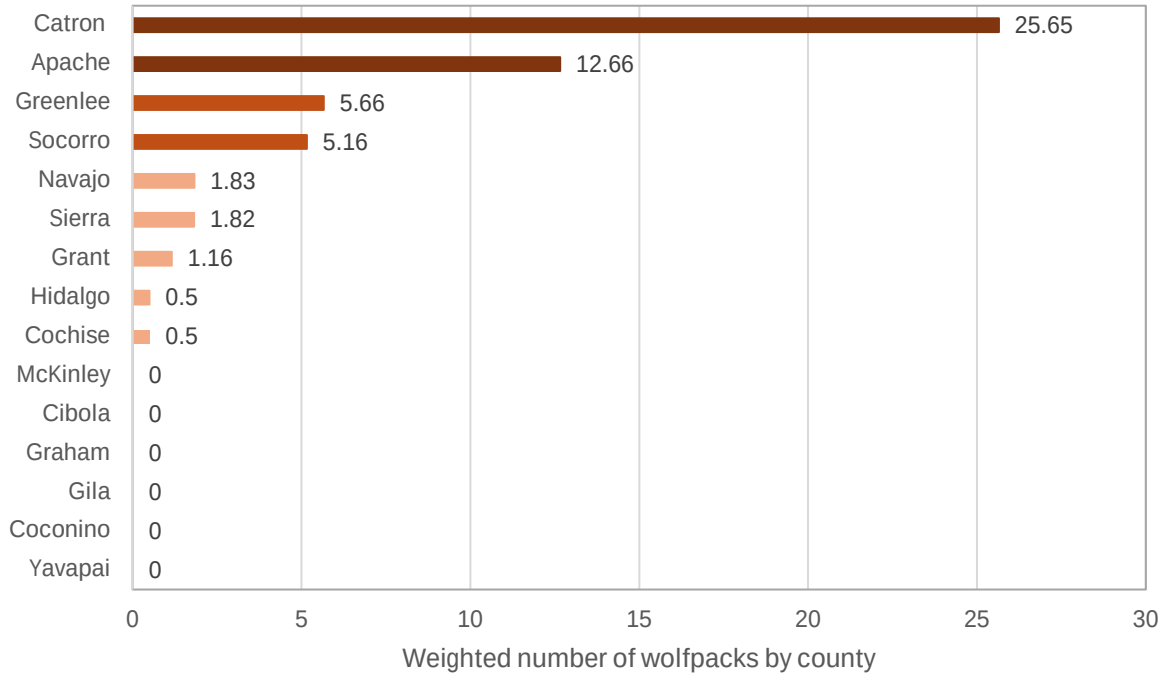
	1 to 9 head	10 to 99 head	100 or more head
Catron			
Percent of ranches	26%	42%	31%
Number of ranches			51
Percent of sales	1%	11%	88%
Cibola			
Percent of ranches	54%	37%	8%
Number of ranches			19
Percent of sales	6%	32%	62%
Grant			
Percent of ranches	46%	37%	18%
Number of ranches			26
Percent of sales	2%	12%	86%
Hidalgo			
Percent of ranches	8%	50%	42%
Number of ranches			30
Percent of sales	0%	14%	85%
McKinley			
Percent of ranches	8%	50%	42%
Number of ranches			30
Percent of sales	0%	14%	85%
Sierra			
Percent of ranches	42%	35%	22%
Number of ranches			22
Percent of sales *	3%	21-31%	65-76%
Socorro			
Percent of ranches	25%	46%	28%
Number of ranches			44
Percent of sales	1%	15%	84%

Source: 2022 Census of Agriculture * Because of USDA disclosure restrictions, more exact estimates are not available.

Wolf Presence and Livestock Sector Performance: County Comparisons

Figure 20 shows the weighted number of wolf packs in each county based on the Mexican Wolf Recovery Program Progress Report #26 (USFWS, 2023). The report lists the names of different packs by county. Figure 20 weights the number of packs in each county as follows. If a pack was reported in a single county, that was counted as 1. If a pack was listed in two counties, each county received a value of 0.5. If a pack was listed in three counties, each of these counties received a value of 0.33. Catron County (score of 25.65) and Apache County (score of 12.66) had by far the most packs. These were followed by Greenlee and Socorro Counties, (with scores between 5 and 6). Four counties (Navajo, Sierra, Grant, Hidalgo, and Cochise had more limited wolf presence). The counties we use as a reference to make the comparisons in the following section reported no packs (McKinley, Cibola, Graham, Gila, Coconino, Yavapai).

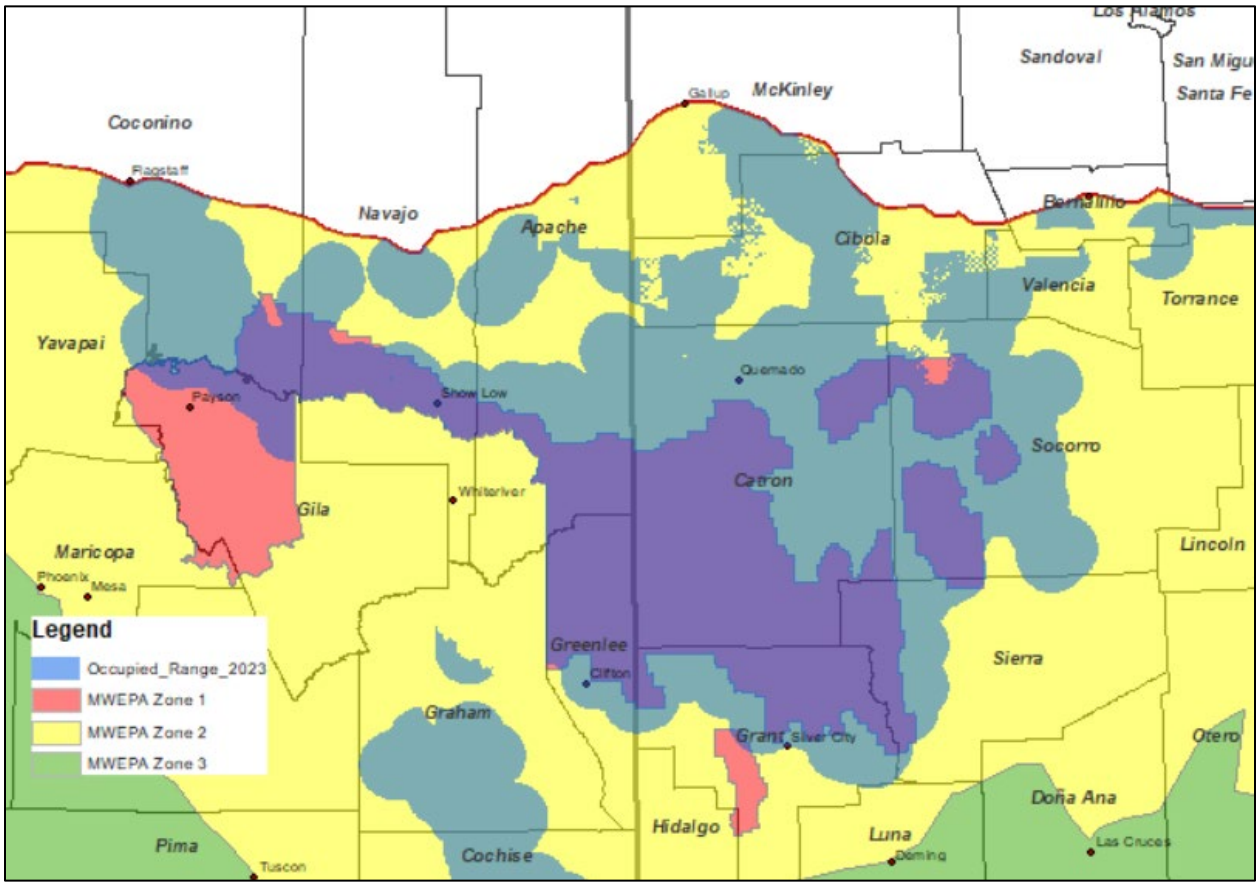
FIGURE 20. WEIGHTED NUMBER OF MEXICAN GRAY WOLF PACKS IN ARIZONA AND NEW MEXICO COUNTIES



Source: Mexican Wolf Recovery Program Progress Report #26

We examined county-level data for cattle inventories and livestock sales revenues over time, comparing counties with high wolf presence with other counties in the region. Counties with high wolf presence were Catron, Apache, Greenlee, and Socorro (Figure 21).

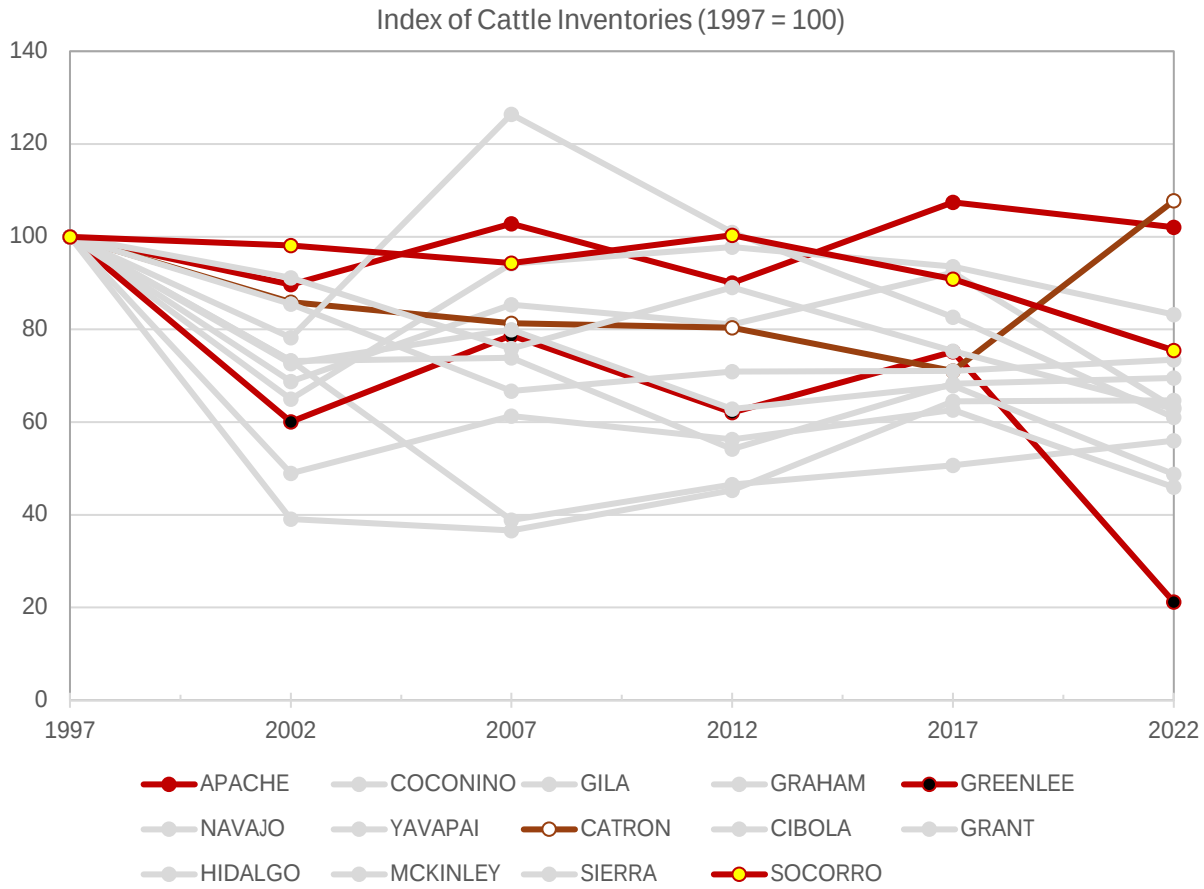
FIGURE 21. MAP OF ARIZONA & NEW MEXICO COUNTIES WITH HIGH WOLF PRESENCE (2023)



Source: US Fish & Wildlife Service

Cattle inventories are indexed to the baseline year of 1997, the year prior to the beginning of wolf reintroduction, for each county (Figure 22). The indexing strategy controls for differences in baseline inventory sizes across counties. It also captures how inventories might change across all counties together over time, in response to common factors, such as cattle prices. An index of 120 means that inventories were 20% higher than in 1997, while a value of 80% means that inventories were 20% lower than in 1997. Inventory data come from the USDA Census of Agriculture (USDA, multiple years) reported every 5 years from 1997 to 2022. The high wolf presence counties are shown in red, while comparison counties are in light gray. For three of the counties with high wolf presence, inventories tended to be higher than in comparison counties. For Greenlee County, inventories were comparable to other counties initially but dropped off more substantially in 2022.

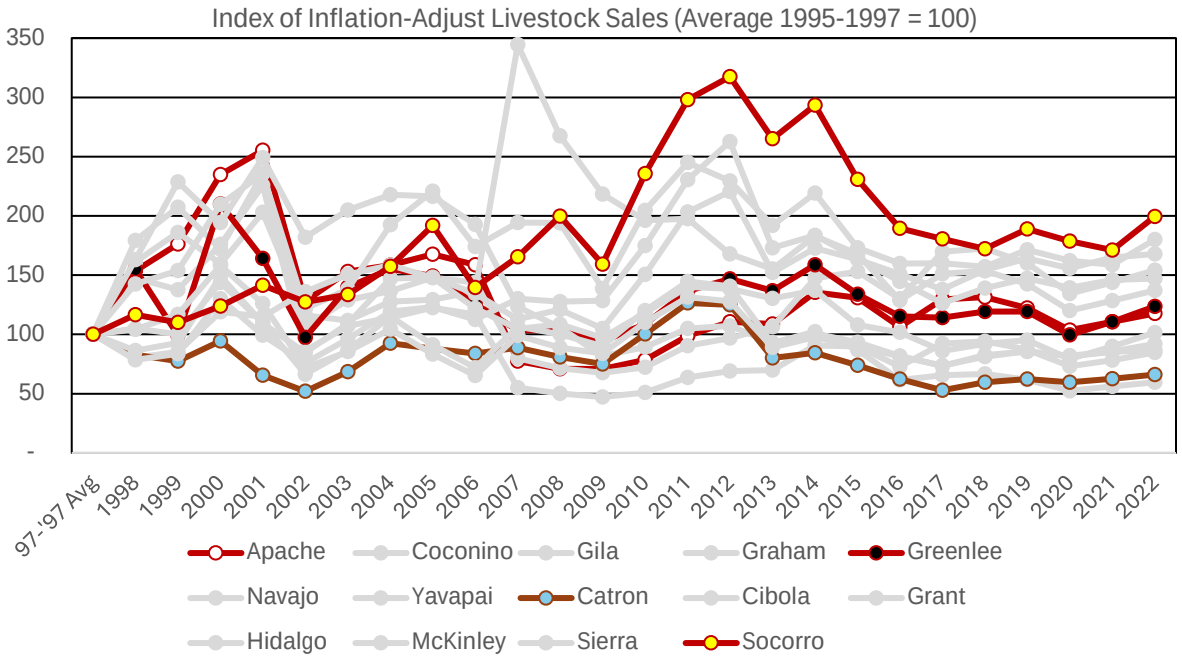
FIGURE 22. CATTLE (INCLUDING CALVES) INVENTORIES IN COUNTIES WITH HIGH WOLF PRESENCE AND COMPARISON COUNTIES



We conducted a similar exercise for the total county-level livestock sales adjusted for inflation. Annual data from the US Department of Commerce Bureau of Economic Analysis from 1995 to 2022 were used. Livestock sales were indexed to the average sales of the years 1995, 1996, and 1997. Three years were chosen as baselines because livestock sales are volatile. We use average values to smooth out anomalies.

Figure 23 reports the changes in sales index values for the counties with high wolf-presence and comparison counties over time. Among the high wolf-presence counties, Socorro County tended to have relatively higher values than most counties, while Apache and Greenlee Counties were comparable to other counties. Index values were generally higher than the pre-wolf reintroduction baseline in these counties, indicating that inflation-adjusted livestock sales have not declined. However, the situation is different for Catron County, where index values were significantly lower than the baseline, particularly in the later years.

FIGURE 23. INFLATION-ADJUSTED LIVESTOCK SALES IN COUNTIES WITH HIGH WOLF PRESENCE AND COMPARISON COUNTIES



We also conducted statistical hypothesis tests on whether cattle inventory and livestock sales were lower in counties with high wolf presence, in comparison to surrounding counties (relative to the pre-reintroduction baseline). Details of the statistical tests are reported in Appendix B. In these tests, the null hypothesis stated that the four counties with the higher number of wolf packs had the same cattle inventories and livestock sales revenues (relative to the pre-reintroduction period) in comparison to counties with few or no packs. The alternative hypothesis was that counties with more wolf packs would exhibit different inventories or sales than comparison counties, with the expected differences being negative.

TABLE 29. TESTS OF HYPOTHESES ABOUT WOLF PRESENCE AND COUNTY-LEVEL LIVESTOCK PERFORMANCE MEASURES

Null Hypothesis	Test Result	Differences between Counties
Cattle Inventories		
Same in Apache County in comparison to counties with few or no packs	Reject	Apache County has higher inventories
Same in Greenlee County in comparison to counties with few or no packs	Fail to Reject	
Same In Catron County in comparison to counties with few or no packs	Reject	Catron County has higher inventories
Same In Socorro County in comparison to counties with few or no packs	Reject	Socorro County has higher inventories
Null Hypothesis	**Test Result**	**Differences between Counties**
Livestock Sales		
Same in Apache County in comparison to counties with few or no packs	Fail to Reject	
Same in Greenlee County in comparison to counties with few or no packs	Fail to Reject	
Same In Catron County in comparison to counties with few or no packs	Reject	Catron County has lower inventories
Same In Socorro County in comparison to counties with few or no packs	Reject	Socorro County has higher inventories

Considering cattle inventories, we failed to reject the hypothesis that inventories in Greenlee County (relative to the pre-introduction baseline) were the same as in comparison counties. While the differences were statistically significant for Catron, Socorro, and Apache Counties, inventories were larger (compared to baseline) than those for comparison counties. Thus, we find no evidence that counties with more wolf packs had lower inventories than comparison counties.

Turning to livestock sales, compared to the baseline, there were no statistically significant differences in Greenlee and Apache Counties from the comparison counties. Livestock sales in Socorro County were higher than in the comparison counties, with this positive difference statistically significant. For Catron County, however, livestock sales compared to pre-reintroduction were lower than comparison counties with this negative difference statistically significant.

Our statistical analysis of the livestock sector performance since wolf reintroduction found no negative difference in cattle inventories between counties with higher wolf pack presence and those with few or no wolf packs. Results were similar for livestock sales.

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Appendices

Appendix A. Budget Update – Data & Assumptions

This report represents an update to the 2018 study "Effects of Depredation and Mexican Gray Wolf Presence on Ranch Returns: Case Study of a Representative Ranch in Arizona" (Bickel et al., 2018). In that study, a representative ranch model was used to simulate the effects of wolf presence on ranch returns (Teegerstrom & Tronstad, 2017). For model runs estimating the effects of wolf presence on short-term returns, the budget model was updated to reflect current input costs and cattle prices. Input costs were adjusted for inflation from 2016 to 2024 values using USDA agricultural input price indices (Table 30).

TABLE 30. INPUT PRICE ADJUSTMENTS

Item	2016 to 2024 Adjustment
Livestock Farms	1.41
Feed	1.49
Machinery	1.42
Supplies & Repair	1.36
Chemicals	1.22
Fertilizers	1.60
Fuels	1.37
Interest	1.51
Tax	1.46
Wages	1.48

Source: USDA NASS (2024); Author calculations

Cattle prices were updated using feeder cattle and slaughter cow and bull price series for the Clovis, NM livestock auction from 2020 to 2024 (USDA AMS, 2025) (Table 31). Calf prices were assumed to be the average of steer and heifer calf prices, and high and low prices were assumed to be one standard deviation above and below the 2020-2024 average.

TABLE 31. CATTLE PRICES USED FOR ANALYSIS, 2020-2024

	2020	2021	2022	2023	2024	2020-2024 Avg.
Heifer Calves						
Average	$151	$160	$165	$213	$247	$192
Std. dev.	$10	$9	$9	$25	$17	$41
Low Price	$141	$151	$157	$188	$229	$131
High Price	$161	$169	$174	$238	$264	$273
Steer Calves						
Average	$166	$176	$179	$232	$269	$209
Std. dev.	$12	$11	$11	$29	$17	$44
Low Price	$154	$165	$168	$203	$251	$139
High Price	$178	$186	$190	$261	$286	$304
Bulls						
Average	$98	$96	$95	$109	$125	$111
Std. dev.	$9	$6	$9	$10	$17	$21
Low Price	$90	$90	$86	$99	$108	$79
High Price	$107	$102	$104	$119	$142	$167
Cows						
Average	$65	$67	$73	$91	$118	$86
Std. dev.	$9	$7	$9	$11	$15	$23
Low Price	$57	$60	$65	$81	$103	$48
High Price	$74	$73	$82	$102	$132	$139

Source: USDA AMS (2025); Author calculations

For modeling long-term returns over 30 years, previously projected prices were replaced with realized prices, while price projections were updated based on current projections. Revenues were estimated using a historic price series from 1998 to 2016 from Bickel et al. (2018) (CattleFax and the Livestock Marketing Information Center (LMIC)), cow-calf operation cost and returns estimates from 2017 to 2023 (USDA AMS), and two projected price series for 2024 to 2027 (USDA AMS and FAPRI). Costs are estimated based on Teegerstrom & Tronstad (2017) and previous cost and return estimates for Arizona (Teegerstrom & Tronstad, 2000). Both budgets provide high and low estimates for variable costs, ownership (fixed) costs, and the total costs per cow. Using the reported high and low estimates of costs per cow, we estimate the average costs per cow for the years 2000 and 2016. Using these two values as fixed, we estimate the costs per cow from 1998 to 2016, assuming the costs of production increase by 2% every year. From 2017 to 2022, costs are adjusted annually using USDA Costs & Returns costs indexed to 2016. For projections from 2022 to 2027, projected costs are based on USDA AMS projections, and ranch revenues are based on an average of USDA AMS and FAPRI projections. Table 32 presents estimated costs and returns for the representative ranch.

TABLE 32. PER-COW ESTIMATED COSTS & RETURNS FOR REPRESENTATIVE RANCH, 1998-2027, NOMINAL USD

Year	Revenue	Total variable costs	Total ownership costs	Total fixed & variable costs	Return over variable costs	Return over total costs
1998	$233	$124	$146	$270	$109	-$37
1999	$277	$126	$149	$276	$151	$2
2000	$297	$129	$152	$281	$168	$15
2001	$295	$131	$155	$287	$163	$8
2002	$257	$134	$158	$293	$123	-$35
2003	$324	$137	$162	$298	$187	$26
2004	$391	$140	$165	$304	$251	$87
2005	$399	$142	$168	$310	$256	$88
2006	$377	$145	$171	$317	$232	$61
2007	$375	$148	$175	$323	$227	$52
2008	$345	$151	$178	$329	$193	$15
2009	$341	$154	$182	$336	$187	$5
2010	$412	$157	$186	$343	$255	$69
2011	$480	$160	$189	$350	$320	$130
2012	$524	$163	$193	$357	$361	$168
2013	$564	$167	$197	$364	$398	$201
2014	$868	$170	$201	$371	$697	$497
2015	$636	$173	$205	$378	$463	$258
2016	$447	$177	$209	$386	$270	$61
2017	$451	$179	$211	$390	$272	$61
2018	$374	$204	$241	$445	$170	-$71
2019	$354	$208	$245	$453	$146	-$99
2020	$359	$207	$245	$452	$152	-$93
2021	$385	$226	$267	$493	$159	-$108
2022	$444	$256	$303	$559	$187	-$115
2023	$512	$246	$291	$537	$265	-$26
2024	$497	$247	$292	$539	$250	-$42
2025	$500	$248	$293	$542	$252	-$42
2026	$502	$250	$295	$545	$252	-$43
2027	$511	$251	$297	$548	$260	-$37

Source: Author calculations

Appendix B. Statistical Tests

Table 33 reports the results of a statistical test examining whether counties with higher wolf presence had lower cattle inventories (relative to the 1997 baseline) than the comparison counties. A simple regression analysis was applied to assess whether average inventories (relative to baseline) were lower in counties with more wolf packs than in counties with few or no packs.

Cattle inventory data, including calves, was obtained from the USDA Census of Agriculture, which is reported every five years for the years 1997, 2002, 2007, 2012, 2017, and 2022. The analysis focused on four counties with relatively high wolf pack presence: Greenlee and Apache in Arizona, and Catron and Socorro in New Mexico. Additionally, data were collected for surrounding counties with few or no wolf packs: Coconino, Gila, Graham, Navajo, and Yavapai in Arizona, and Cibola, Grant, Hidalgo, McKinley, and Sierra in New Mexico.

Inventories were converted to index values by dividing values in a county by that county's inventories in 1997 (the year before the beginning of the Mexican gray wolf introduction) and then multiplying by 100. Each county then had an inventory value of 100 in 1997. Index values for subsequent years represent percentage differences in inventories relative to the 1997 baseline. Indexing serves two purposes: it adjusts for differences in baseline inventory sizes across counties and captures changes in inventories over time that may be influenced by common factors, such as cattle prices. For example, an index value of 120 indicates that inventories were 20% higher than in 1997 for that county, while an index value of 80 indicates that inventories were 20% lower than in 1997 for that county.

Cattle inventories for the years 2002, 2007, 2012, 2017, and 2022 for 14 counties, including four with high wolf presence and 10 with low or no wolf presence, resulting in a total of 70 observations. The regression analysis used cattle inventory index values as the dependent variable. To account for potential differences associated with high wolf presence, dummy variables were included for Apache, Greenlee, Catron, and Socorro counties.

Table 33 presents the results. The intercept of 69.94 indicates that, on average, inventories across all counties were approximately 70% of their 1997 baseline levels. The coefficients for high-presence counties measure how much inventories in these counties differed from the overall average. The coefficients report deviations from the intercept value of 69.94 attributable to a specific county. The remaining columns assess the statistical significance of these differences.

TABLE 33. TESTS OF HYPOTHESES ABOUT WOLF PRESENCE AND COUNTY-LEVEL LIVESTOCK PERFORMANCE MEASURES

Adjusted R Square: 0.224				
Observations: 70				
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	69.94	2.43	28.78	0.00
Greenlee	-10.50	8.06	-1.30	0.20
Catron	15.32	8.06	1.90	0.06
Apache	28.45	8.06	3.53	0.00
Socorro	21.86	8.06	2.71	0.01

A similar exercise was conducted for livestock sales, focusing on total county-level inflation-adjusted sales. Annual data from the US Department of Commerce Bureau of Economic Analysis (BEA, 2024) from 1995 to 2022 were used. Livestock sales were indexed to the years 1995-1997 to establish a baseline. This three-year

average was chosen to smooth out anomalies due to the inherent volatility of livestock sales, reducing sensitivity to the choice of a single base year.

The regression analysis was applied to data from the 14 counties for the years 1998 to 2022, resulting in 350 observations. As with the inventory analysis, dummy variables were included for high wolf presence counties to test whether their sales index values differed from those of comparison counties (see Table 34).

TABLE 34. TESTS OF HYPOTHESES ABOUT WOLF PRESENCE AND COUNTY-LEVEL LIVESTOCK SALES MEASURES

Adjusted R Square: 0.158				
Observations: 350				
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	129.82	2.92	44.44	0.000
Greenlee	-0.95	9.69	-0.10	0.922
Catron	-51.16	9.69	-5.28	0.000
Apache	1.77	9.69	0.18	0.855
Socorro	57.65	9.69	5.95	0.000

Results can be interpreted similarly to the previous analysis.

Appendix C. Survey Instrument

January 2025

Dear Cattlegrower:
This survey is part of an ongoing effort by University of Arizona Cooperative Extension, the Arizona Cattle Growers' Association, and the New Mexico Cattle Growers' Association to understand the economic effects of Mexican wolves on cattle ranching communities. This survey is directed to Arizona and New Mexico ranchers in and around areas where Mexican wolves are present. If you've been affected by wolves in the past, the survey seeks to better understand how you've been affected. If you haven't been directly affected by wolves so far, the survey seeks to better understand the situation and concerns of people who might be affected in the future.

The survey is broken into four parts:

1. General questions regarding your ranching operation
2. Questions regarding your interactions with wildlife, in particular Mexican wolves
3. Questions about management practices used to avoid or reduce wolf impacts
4. Questions about your experience with current and past compensation programs

Please answer questions to the best of your ability. In cases where you do not know exact figures, please provide your best estimate. It may be helpful to have records related to any compensation for wolf depredation or conflict avoidance available as you answer this survey, if applicable.

If at any time you wish to discontinue the survey, you are free to do so. If you would like to receive a phone call to complete the survey by phone, please contact us at duval@arizona.edu, providing your contact information, and we will reach out to schedule a call at your convenience. *All survey responses will be kept strictly confidential*.

If you have any questions or require any clarification in completing the survey, please contact us at duval@arizona.edu and we will respond as quickly as possible.

Thank you for your valuable time and input!

1. Are you a rancher / beef producer?

- ÿ Yes
- ÿ No (if No, please end survey here. Thank you for your time)

2. County and State where your ranch is located: _____

3. Zip code where your ranch is headquartered: _____

4. How long have you operated this ranch? (in years): _____

5. Composition of your ranch by land tenure and land management agency (total should sum to 100):

BLM :	_____
USFS :	_____
State :	_____
Private (owned) :	_____
Private (leased) :	_____
Other :	_____
Total :	_____

6. Average breeding herd size of your operation from 2021-2023: _____

7. In recent years (2021-2023), what is your annual average:

- ÿ Percent breed back _____
- ÿ Percent live calves of pregnant cows _____
- ÿ Percent calf crop _____
- ÿ Percent heifer calves retained as replacements _____
- ÿ Annual cow culling rate _____
- ÿ Annual cow death loss from **all** causes _____
- ÿ Annual yearling death from **all** causes _____
- ÿ Annual calf death loss from **all** causes _____
- ÿ Cow to bull ratio _____

8. Average number and sale weight of cattle and calves sold annually from your operation from 2021 to 2023:

	Average number sold	Average sale weight
Calves		
Yearlings		
Cull Cows		
Cull Bulls		

9. What percentage of your household income comes from ranching?

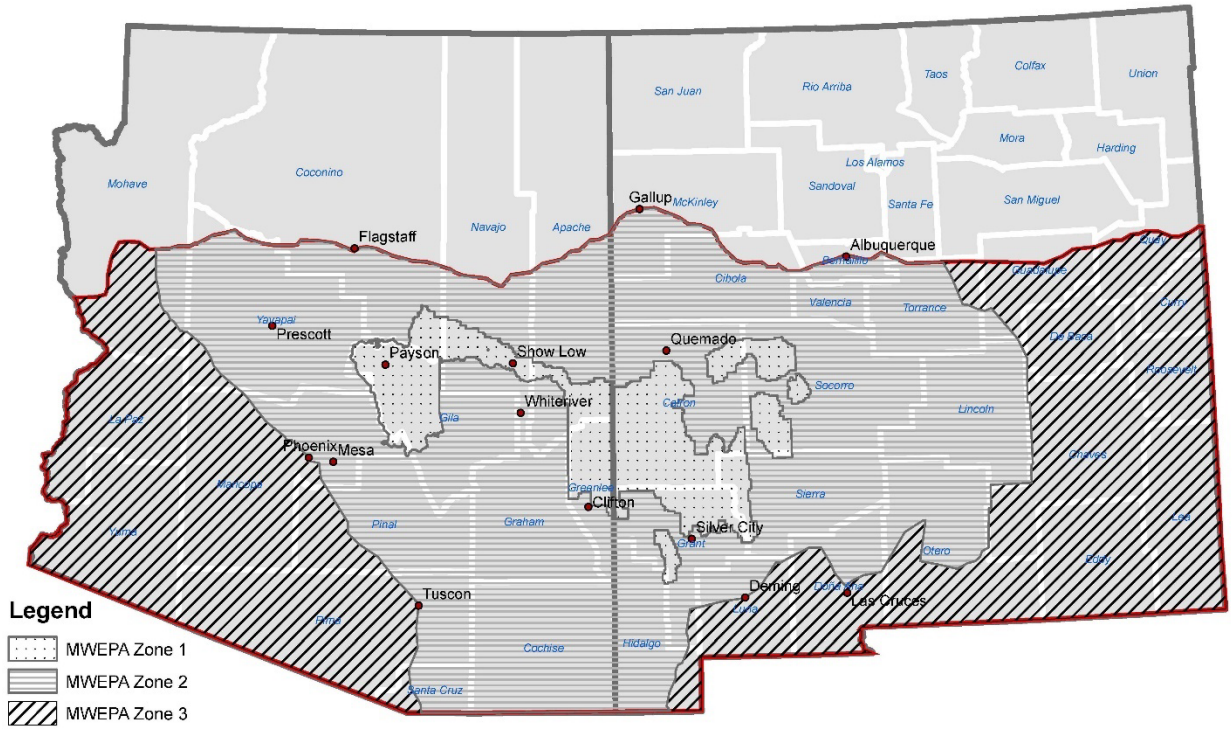
- ÿ Less than 25%
- ÿ 25% to 49%
- ÿ 50% to 75%
- ÿ More than 75%

Rancher Interactions with Wildlife

10. Please read the following statements and select your most appropriate response

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
The success of my ranching operation is tied to the health of the ecosystem	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Predators are part of a healthy ecosystem	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
The presence of predators and other wildlife on public lands is a part of nature that comes with operating on these lands	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Too much of the responsibility for ensuring populations of threatened and endangered species is borne by ranchers operating on public lands and not enough by others	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
I support maintaining a healthy wild population of Mexican wolves	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Mexican wolf depredation is a more serious problem than depredation by other large predators	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Mexican wolf depredation has become a more serious problem over the past 10 years	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
The economic impacts I have experienced from Mexican wolves to my beef operation are tolerable	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Mexican wolf presence is a threat to the ranching way of life	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
I would be more accepting of the presence of Mexican wolves if compensation covered its full (direct and indirect) costs	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ

11. Is your ranch located either fully or partially in the Mexican Wolf Experimental Population Area? (area outlined below)



- ÿ Yes, mostly in Zone 1 (dotted area)
- ÿ Yes, mostly in Zone 2 (horizontal gray bars)
- ÿ Yes, mostly in Zone 3 (diagonal black bars)
- ÿ No
- ÿ I don't know

12. Has your beef operation been impacted by wolves?

- ÿ Yes, directly through depredation or injury and indirectly through stress or other impacts
- ÿ Yes, directly through depredation or injury only
- ÿ Yes, indirectly through stress or other impacts only (Please skip to Question 22)
- ÿ No (Please skip to Question 23)
- ÿ I'm not sure. Please explain. _____

13. What are the lowest, typical, and highest annual number of animals lost due to wolf depredation on your ranch? Please indicate in the table the number of wolf depredations for each type of animal. This includes all reported depredations, unreported depredations, and missing cattle that you believe were lost due to wolves.

	Cow	Bull	Yearling	Calf	Horse	Dog
Lowest Annual Death Loss Due to Wolves						
Typical Annual Death Loss Due to Wolves						
Highest Annual Death Loss Due to Wolves						

14. What year did you experience the highest number of cattle lost due to wolf depredation?

Year _____

Total number of cattle depredated in that year _____

15. Please indicate in the table how many wolf depredations occurred in 2021, 2022, and 2023 categorizing them by whether they were reported and confirmed by Wildlife Services, County Investigator, or other third parties that determine compensation eligibility.

	Depredations **Confirmed** by a Third Party			Depredations **Determined Probable** by a Third Party			Depredations Reported but **Not Determined Confirmed or Probable** by a Third Party			Unreported		
	2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
Calves												
Yearlings												
Cows												
Bulls												

16. If you have had an unreported depredation incident(s), please provide the reason(s) for not reporting. Please select all that apply.

ÿ Difficulty to prove

ÿ Delay in receiving compensation

ÿ Time and resources required to file for compensation

ÿ Amount of compensation not enough

ÿ Other, please specify _____

17. How have you responded to the loss of the calf or cow due to wolf depredation? If multiple depredations, please use space below to elaborate.

- ÿ Retained a calf that would otherwise have been sold (Please skip to Question 21)
- ÿ Retained a yearling heifer that would otherwise have been sold (Please skip to Question 21)
- ÿ Purchased a yearling heifer as replacement
- ÿ Purchased a bred heifer as replacement
- ÿ Purchased a bred cow
- ÿ Purchased bred pairs
- ÿ Other. Please describe: _____

18. Generally, how long after the loss of the animals above were replacements purchased?

- ÿ 1-3 months
- ÿ 3-6 months
- ÿ 6-9 months
- ÿ 9-12 months
- ÿ Greater than 12 months
- ÿ Not applicable

19. How do you typically finance the purchase of replacements?

- ÿ Cash
- ÿ Loan
- ÿ Personal loan
- ÿ Depredation compensation

20. Additional costs (other than animal purchase costs) that were associated with replacement cattle? Report costs per depredation.

Travel costs _____
Labor costs _____
Other costs or fees _____
Your time _____

21. Please provide the highest, lowest, and typical annual cost of additional veterinary care and medicine to treat injuries to cattle due to wolves:

Highest Annual Cost _____
Typical Annual Cost _____
Lowest Annual Cost _____

22. In which of the following ways, if any, has your beef operation been indirectly impacted by wolves through stress or other impacts? Please select all that apply and, if applicable, estimate percent increase or decrease that you consider attributable to wolves:

	Indirect Effect	Percent Change	Direction of Change
	Select all that apply	%	
Change in weaning weights	ÿ		ÿ Increase ÿ Decrease
Change in conception rates	ÿ		ÿ Increase ÿ Decrease
Change in cattle disease / sickness	ÿ		ÿ Increase ÿ Decrease

23. Has the presence of wolves caused you to consider selling your ranch?

- ÿ Yes, and the property has been listed for sale in the past
- ÿ Yes, but the property has not been listed for sale (Please skip to Question 25)
- ÿ No (Please skip to Question 25)

24. Have you experienced any difficulty in finding interested buyers due to wolf presence?

- ÿ No
- ÿ I don't know
- ÿ Yes, please explain: _____

25. Please select the response that best characterizes your experience with Mexican wolf impacts

- ÿ My ranch operation has been impacted by wolves more than other ranches in my area
- ÿ My ranch operation has been impacted by wolves about the same as other ranches in my area
- ÿ My ranch operation has been impacted by wolves less than other ranches in my area
- ÿ I'm not sure how the wolf impacts I've experienced compare with other ranches

26. Please select the response that best represents your beliefs about the future effects of Mexican wolves on your ranching operation

- ÿ The impacts of Mexican gray wolves on my ranch will improve in the future (fewer impacts)
- ÿ The impacts of Mexican gray wolves on my ranch will stay the same in the future
- ÿ The impacts of Mexican gray wolves on my ranch will get worse in the future (more impacts)
- ÿ I do not know

27. *Excluding any influence of Mexican wolves on your operation*, how would you say that your operation is doing financially compared to 5 years ago?

- ÿ Much better off
- ÿ Better off
- ÿ About the same
- ÿ Worse off
- ÿ Much worse off

28. *Excluding any influence of Mexican wolves on your operation*, how would you say you expect your operation will be doing 5 years in the future?

- ÿ Much better off
- ÿ Better off
- ÿ About the same
- ÿ Worse off
- ÿ Much worse off

Management Practices Used to Avoid or Reduce Wolf Impacts

The following section of the surveys asks questions about practices used on your ranch to **avoid or reduce wolf impacts**. The first question asks what practices are used on your ranch, the second question asks about out-of-pocket expenses, and the third question asks about the time you personally devoted to these activities. Please list any additional practices used in the blank spaces provided.

29. Management practices used, if any, to reduce risk of wolf depredation. Please select all that apply.

- ÿ Removal of livestock carcasses
- ÿ Guard animals
- ÿ Range riders / human presence
- ÿ Deterrents or barriers such as fencing or fladry (flag fencing)
- ÿ Changing / shortening calving season
- ÿ Corralling or grouping cattle in an enclosed area
- ÿ Changing pasture rotation or otherwise moving or hauling cattle
- ÿ Others, please explain: _____

30. Annual out-of-pocket expenses for management activities to avoid or reduce wolf impacts from 2021 to 2023. **Please include costs of materials and supplies as well as any payments to hired labor. Do not include any cost share expenses covered by public agencies and NGOs.**

	2021	2022	2023
Expenses associated with the removal of livestock carcasses			
Guard animal expenses			
Wages / salaries for range riders			
Installation of deterrents (fencing, fladry, etc.)			
Expenses associated with hauling / moving cattle			
Additional expenses for feed / supplements			
Others, please explain:			
Total			

31. For supplies purchased for management practices to deter wolf depredation, what percentage was purchased by you:

In-state, in the same county as your ranch	
In-state, in different county	
Out-of-state	

32. Annual hours that you and your staff devoted to management activities to avoid or reduce wolf impacts from 2021 to 2023.

	2021	2022	2023
Watching the herd			
Installing deterrents (fencing, fladry, etc.)			
Hauling / moving cattle			
Removing attractants			
Others, please explain:			
Total			

33. What maintenance or other ranch duties have been postponed in order to find depredations, implement practices to deter wolf depredations, or attend meetings or other activities due to wolves?

_____
_____
_____
_____
_____

Compensation

34. Have you received compensation for any wolf depredation(s)?

- ÿ I have not applied for depredation compensation (please skip to question 37)
- ÿ Yes, in all cases
- ÿ Yes, in some cases
- ÿ No, but I have applied for compensation

35. Approximately how many hours of ranch staff time (including yourself) was spent filing for compensation per incident (carcass inspection, correspondence, travel, paperwork, etc.)

_____

36. How long has it taken (days, weeks, or months) to receive compensation after filing? If multiple incidents, please provide average.

_____

37. Have you received compensation through a Payment for Presence program?

- ÿ No, and I was not aware of the program
- ÿ No, but I am aware of the program and chose not to participate for the following reasons

  _____
- ÿ Yes. Please estimate the amount compensated and the preventative measures taken

  _____

38. Which compensation programs have you directly or indirectly worked with? Please select all that apply.

- ÿ Defenders of Wildlife
- ÿ Mexican Wolf Livestock Coexistence Council
- ÿ Arizona Livestock Loss Board
- ÿ Mexican Wolf Fund
- ÿ USDA Livestock Indemnity Program (LIP)
- ÿ New Mexico County Livestock Loss Authority
- ÿ None of the above
- ÿ Other, please specify _____

39. Please rank the following statements, selecting your most appropriate response

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Compensation for depredations is adequate to cover depredation related losses	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Compensation is timely	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Compensation programs place too much of the burden of proof on ranchers	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Compensation is worth the effort	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Compensation program procedures and requirements are too complex	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Compensation encourages cooperation between ranchers and wildlife conservation	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ
Compensation covers the full costs (direct and indirect impacts) of wolf presence	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ	ÿ

40. Are compensation programs effective? How might they be improved?

_____
_____
_____
_____
_____

41. Besides compensation, what are other management tools that may assist ranchers experiencing wolf depredation issues?

_____
_____
_____
_____
_____

42. Please provide any additional comments you may have regarding Mexican wolf presence and compensation.

_____
_____
_____
_____
_____

43. If you would like to make any additional comments or provide clarification on survey responses, please provide your name and phone number so that we may contact you for a follow-up phone call.

Name _____

Phone Number _____