AN HOURGLASS HIDDEN IN THE GENOME

How To Help The Endangered Mexican Gray Wolf Outrun Inbreeding



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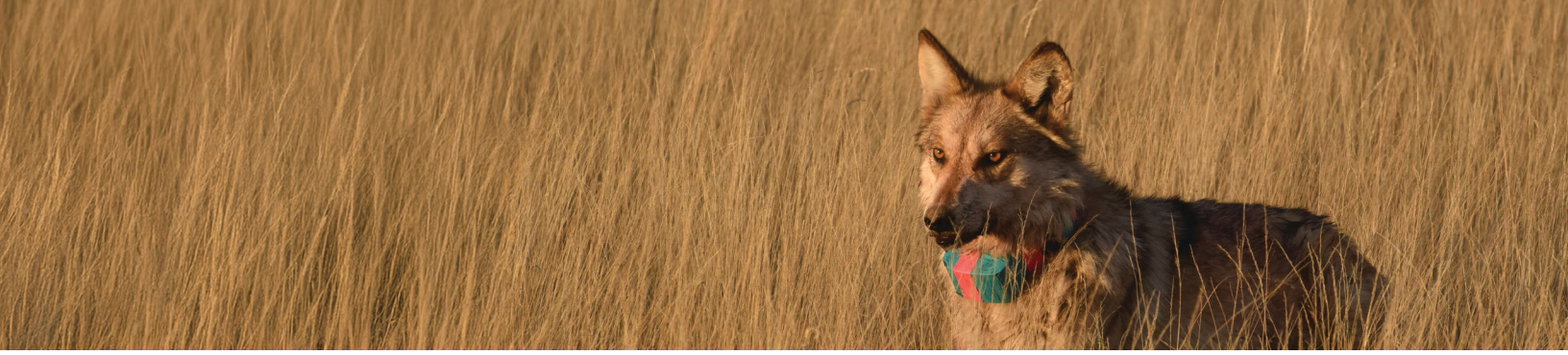

EXECUTIVE SUMMARY

Almost three decades after the 1998 reintroduction of endangered Mexican gray wolves in the Southwest, the joint federal, state and Tribal effort has increased wolf numbers in the wild from zero to over 300, now distributed over several million acres in western New Mexico and eastern Arizona.

Yet, management actions decreased the genetic diversity inherited from the original seven wild-born wolves bred decades earlier in captivity – leaving the equivalent of the genetic diversity from just over two wolves in the reintroduced population.

Growing numbers of the Mexican wolf do not signify recovery while the population's genetic health remains dire. Values for three genetic metrics in the wild population remain stagnant: mean kinship, percent gene diversity retained and founder genome equivalents. Even worse, the values in the fourth tracked metric – inbreeding coefficients – continue to deteriorate.

No animal population is known to have been as inbred as is the wild United States population of Mexican wolves and survived.

Peer-reviewed science along with scrutiny of what has not worked in the past, point toward three new policies and associated management measures that will recover the Mexican wolf and lead to a future scientific consensus that the subspecies is ready to be taken off the endangered species list:

1. Release captive-born wolf families to the wild;
2. allow wolves to roam freely; and,
3. stop removing wolves for having killed livestock.

Understanding the consequences of current management will enable policy makers to avoid a future in which the Mexican wolf never leaves the federal endangered species list and ultimately goes extinct.

It is instead possible to fulfill the noble purposes of the Endangered Species Act to conserve the Mexican wolf and the ecosystem upon which it depends. Our explanations of those three policy reforms in the pages to follow show how this ecologically vital mammal which is unique to our arid region can be recovered through scientific management.

1. RELEASE CAPTIVE-BORN WOLF FAMILIES TO THE WILD.

Why?

The captive population of Mexican gray wolves retains almost 40% more genetic diversity than the wild population in the Southwest.[1] Up through 2006, wildlife managers released family groups of well-bonded,

breeding Mexican wolves and their pups together from captivity. The strong family ties among wolves led to a high survival rate which enabled establishment of the wild population.

Livestock industry pressure halted that successful practice, and over the ensuing 10 years the interagency Mexican wolf field team haphazardly released just five wolves – with none given sufficient time to bond with other wolves and none ending up surviving for long in the wild. After genetic diversity had substantially declined, beginning in 2016, agencies began removing captive-born neonatal pups from their parents and releasing them into the dens of wolves in the wild. This has led to most of the pups disappearing – presumed dead – accompanied by stagnating genetic diversity in the wild.

Low genetic diversity in Mexican wolves is associated with fewer pups born and/or less of them surviving. Artificial feeding has boosted wild wolf pup survival but also masks the inbreeding through treating the symptom and not the cause. Resuming releases of family groups – that is, releasing the parents with their pups – would promote the population's genetic health.

A Deeper Dive...

The U.S. Fish and Wildlife Service's 1998 reintroduction rule called for releasing "family groups" of Mexican wolves from captive-breeding facilities to the wild,[2] and the agency later reported that 66% "of the initial released breeding animals with dependent pups in areas of adequate native prey have been successful," defining success as a "released wolf that survives and produces pups in the population in the future."[3]

In contrast to the two-thirds rate of survival and subsequent breeding among the adults who had been released with their families between 1998 and 2006, among the 143 captive-born pups separated from their mothers and released into the wild between 2016 and 2025, just 20% were ascertained to be alive in their first winter or at any time thereafter.[4]

With few pups initially surviving and only a fraction of them reaching adulthood and reproducing, genetic diversity in the wild population has continued to decline.[5]



What's Wrong With The Status Quo?

During the two-decade absence of releases of well-bonded, captive-born Mexican wolf families, inbreeding has increased in the reintroduced U.S. population. The first year that comprehensive genetic values were calculated for the population was 2005, when mean kinship (i.e. average relatedness) was found to be 0.2277.[6] (A kinship value of zero would mean that animals in the populations are not related at all, while a value of one would mean that they are identical.) By 2026, mean kinship had risen five percent to 0.2401.[7] Similarly adverse changes occurred in the three other metrics that geneticists monitor for Mexican wolves.

Peer-reviewed research published in 2007, when greater variation existed among Mexican wolves in the wild than exists today, demonstrated that more closely-related Mexican wolves who mated together bore fewer pups and/or fewer survived after birth, on average, than did less closely-related mated pairs and their pups.[8] A 2026 study of captive Mexican wolves came to the same conclusion.[9]

Other genetic alarm bells continue to ring. In 2012, researchers documented that over the previous decade, 14 Mexican wolves contracted rare nasal carcinomas thought to be genetically caused.[10] And in this decade, Mexican wolves are being born with their toes fused together, a congenital condition which had plagued the Isle Royale, Michigan wolf population as it dwindled to two animals as a consequence of inbreeding.[11] (The Isle Royale wolf population was then resuscitated through releases of wolves captured from Canada.)

How To Do It Right:

Multiple captive-born family packs of Mexican gray wolves, selected for their genetic value, should be released onto public lands in the Southwest. Each family should consist of a male/female pair who had been penned together for at least six months, and their pups. Initially, family packs should be released into the largely-wolfless southern portion of the Gila National Forest, including areas within the Gila Wilderness and the Pinos Altos Range.

Concurrently, the Fish and Wildlife Service should revise its 2022 Mexican wolf 10(j) management rule to enable releases of Mexican wolves anywhere on suitable public lands within Arizona and New Mexico and within the southern third of Colorado and Utah.

2: ALLOW WOLVES TO ROAM FREELY.

Why?

Unconstrained dispersal of young adult wolves is important for enabling the reconnection of Mexican gray wolves with gray wolves to the North. Meetings, matings, pup rearing and genetic intergradation between gray wolf subspecies occurred over the course of millennia, and are now vital to adding genes from gray wolves to the genetically depauperate Mexican wolf population.

Nonetheless, federal and state policy calls for removal and translocations of all Mexican wolves north of Interstate 40 (as well as any who might venture west of Arizona or east of New Mexico). Policies also call for removal of most northern wolves entering New Mexico or Arizona.

Yet, eleven Mexican wolves are known to have ventured north of I-40 since reintroduction began.[12] A growing population means that many more Mexican wolves will cross I-40 and it will soon be a Sisyphean and endlessly expensive task to capture and return each one.



A Deeper Dive...

Fish and Wildlife Service scientist Edward A. Goldman published the first comprehensive taxonomy of gray wolf subspecies in 1944 based on pelage and measurements of bones and skulls. "In southeastern Arizona and southwestern New Mexico, *[Canis lupus] baileyi* intergraded with *[Canis lupus] mogollensis,*"[13] he wrote, referring respectively to the Mexican wolf and the Mogollon Mountain wolf, an extinct putative subspecies that in 1983 was to be synonymized with the Mexican wolf by two other Service scientists. In turn, "[t]he Mogollon Mountain wolf is somewhat intermediate in characters, as well as in geographic position, between *[Canis lupus] youngi* and the smaller race *baileyi*,"[14] Goldman wrote, referring in the former to the southern Rocky Mountain wolf. He added: "Evidence of intergradation is clear."[15]

Geneticists identify fewer subspecies than morphological taxonomists such as Goldman but also discern long-term breeding between members of different subspecies, such as in a 2004 study based on museum specimens that found "genetic evidence of intergradation of Northern and Mexican wolf-related haplotypes," which led the three authors to opine "that Mexican grey wolves or a mix of Canadian and Mexican grey wolves could be introduced to a wider area . . . to mimic past intergradation."[16] And even before inbreeding depression had been diagnosed in Mexican wolves, in additional support of their recommendations they noted that "[i]n highly mobile species, large zones of intergradation may characterize subspecies boundaries and provide important sources for adaptive evolution."[17]

Other scientists expressed disagreement with confining Mexican wolves. Four independent experts who wrote the Service's 2001 three-year review of the reintroduction program opined that geographically confining wolves "needlessly excludes habitat that could substantially contribute to recovery."[18] The American Society of Mammalogists in 2007 advised agencies to "allow wolves to roam freely throughout the Southwest."[19] In 2014, a peer-reviewed study demonstrated that genetic recovery and reducing the risk of Mexican wolf extinction to less than 10% over 100 years would require establishment of three connected populations that together

would serve as a metapopulation, totaling a minimum of 750 wolves, and including populations in the southern portion of the southern Rocky Mountains and in the Grand Canyon ecosystem – both north of I-40 – in addition to the current population at the headwaters of the Gila River.[20]

And in 2025, seven biologists wrote in the *Journal of Wildlife Management:*

> *Because Mexican wolves are so low in genetic variation and have shown inbreeding depression, they are in need of genetic rescue. Expansion northward resulting in crosses with northern gray wolves, such as those currently being established in Colorado, would provide an appropriate cross to further ameliorate the negative effects of inbreeding depression and increase genetic variation.*[21]

Agency opposition that is based on concern for the subspecific integrity of the Mexican wolf does not account for the ten-to-one ratio of Mexican wolves in the Southwest to northern gray wolves in Colorado. Such opposition also does not account for the 1995 genetic rescue of endangered Florida panthers suffering from low population fitness through the translocations of eight female Texas pumas to their habitats. Five of those Texas pumas bred with Florida panthers and thereby reduced the incidences of cryptorchidism (undescended testicles) and low sperm quality that impaired the population's fertility.[22]

What's Wrong With The Status Quo?

Even if and when all of the remaining genetic diversity inhering in the captive population of the Mexican gray wolf becomes successfully replicated in the southwestern wild population as a consequence of adoption of our recommended first policy reform to release family packs, the wild population would still only retain the equivalent of fewer than three founding animals, or to be precise, 2.84 founder genome equivalents, which is the figure for that metric in the captive-breeding population.[23] That is too low for long-term viability.

A peer-reviewed study published in 2010 warned: "If the reintroduced population does not increase soon, it may be necessary to consider extraordinary measures, such as introducing northern gray wolves, a closely related subspecies (Leonard et al. 2005), into the reintroduced Mexican wolf population."[24] Those authors assumed that an increased population would partially be accomplished through successful releases from captivity and would be accompanied by increases in genetic diversity. However, since 2010, despite the population increasing, genetic diversity declined.[25] Conditions now necessitate precisely the intergradation that scientists over a decade and a half ago predicted might be needed.

How To Do It Right:

Federal and state agencies should stop removing Mexican gray wolves who travel on their own north of Interstate 40, and should stop removing northern gray wolves emanating from or traveling through Colorado and who enter New Mexico or Arizona.

Concurrently, the Fish and Wildlife Service should revise its 2022 Mexican wolf 10(j) management rule to disavow its commitment to removing wolves who leave the Mexican Wolf Experimental Population Area, and, in a complete reversal, instead authorize wolf releases in suitable habitats north of I-40.

The Service should also revise the 2022 Mexican Wolf Recovery Plan to establish additional recovery areas for Mexican wolves in the southern Rocky Mountains of northern New Mexico and southern Colorado, and in the Grand Canyon ecosystem of northern Arizona and southern Utah.

3: STOP REMOVING WOLVES FOR HAVING KILLED LIVESTOCK.

Why?

Since Mexican gray wolf reintroduction began in 1998, federal, state and Tribal employees have deliberately killed 28 wolves in response to predation on livestock.[26] An additional 84 have been removed alive for that reason, of whom 17 died as unintended direct consequences of their captures.[27]

Most of the live-captured wolves who survived have taken up pen space that otherwise would have provided capacity for additional captive breeding. The wolf captures thereby hastened the erosion of genetic diversity in the captive population, where some wolves who otherwise might be bred are administered birth-control drugs because of the paucity of pen space that would be needed for future pups.

Most acutely, wolf removals have contributed to the more-rapid loss of genetic diversity in the wild population.

And whether lethal or non-lethal, removing wolves is also cruel, sometimes resulting in the breaking up of families and the orphaning of pups.[28]

A Deeper Dive...

Since the advent of federal predator extermination through a 1915 Congressional appropriation, the greatest cause of the Mexican wolf's demise in the United States was the deliberate trapping, poisoning and den-excavating of Mexican wolves by federal employees on behalf of the livestock industry.[29]

The 1998 reintroduction program that should have been shaped by the conservation values of the 1973 Endangered Species Act was instead molded around the same sensibility of scapegoating wolves who prey on livestock.

Removals have haphazardly targeted genetically valuable wolves, including the Saddle Pack alpha male described before he was shot in 2004 as "not considered 'surplus' or 'genetically redundant.'"[30]

In 2007, the American Society of Mammalogists recommended that the Fish and Wildlife Service "suspend all predator control directed at Mexican gray wolves."[31] In 2008, the Association of Zoos and Aquariums requested of the Service a "moratorium on lethal control and permanent removal . . . of Mexican wolves . . . until an expert taskforce on genetic issues can be convened to provide guidance to these actions."[32] The Service did not convene such a task force. In part because the agency disregarded the mammalogists' and the zoos' and aquariums' recommendations, genetic diversity is significantly lower in the wild population today than it was in 2007 or 2008.[33]

A feasible alternate program to the ongoing practice of removing Mexican wolves would consist of comprehensively deterring and ultimately preventing their predations on livestock. In 2023, scientists and wolf managers advised that Mexican wolf recovery "requires greater tolerance for conflict and more emphasis placed on preventive techniques."[34] Studies from regions where wolves live in proximity to livestock have shown that a variety of preventive techniques are at least as effective in protecting domestic animals as is the practice of removing wolves.[35]

Properly disposing of livestock carcasses before wolves scavenge is widely considered essential to minimizing exposure of wolves to potentially vulnerable livestock. The 2001 Mexican wolf three-year review stated that "livestock producers using public land in occupied wolf range should be required to exercise reasonable diligence in finding livestock that have died to either dispose of the carcass or enable the [Fish and Wildlife]

Service to do so."[36] The 2007 American Society of Mammalogists suite of recommendations for Mexican wolf recovery advised the Service to "protect wolves from the consequences of scavenging on livestock carcasses."[37] In 2011, researchers in Alberta, Canada where wolves and cattle overlap recommended "sanitary disposal of dead livestock to prevent wolves from becoming accustomed to feeding on livestock"[38]

Beyond proper carrion disposal, other proactive safe-husbandry practices can also make a difference, and even before wielding actual deterrent measures. For example, that same year, 2011, after having monitored 930 radio-collared cattle within Mexican wolf range for 3.5 years to analyze calf mortality, researchers recommended "decreasing the temporal extent of the birth pulse" to reduce vulnerable calves' exposure to a variety of predators.[39]

What's Wrong With The Status Quo?

Wolf removals in the wake of losses of livestock follow political rather than biological imperatives, with devastating genetic consequences. Ranchers receive compensation after wolves kill their livestock, even if



they had done nothing to prevent those conflicts. This creates a financial incentive not to robustly protect domestic animals, which then too often results in dead wolves.

In 2025, three genetically valuable packs were harmed through removals: the Bear Canyon Pack whose alpha female was gunned down by USDA Wildlife Services while she had dependent pups (who were not saved),[40] the Mañada del Arroyo Pack that had four members captured by Arizona Game and Fish Department (who were recently released in Mexico) while the department deliberately killed a pup who they could not capture,[41] and the Dillon Mountain Pack whose three-month-old pup was shot from the air by Wildlife Services.[42] In 2026, the agency killed another genetically valuable Dillon Mountain Pack wolf.[43]

Unless the agencies stop removing wolves as a response to wolves killing livestock, the Mexican wolf will remain on the federal endangered species list as past progress towards recovery continues to be squandered.

How To Do It Right:

Agencies should stop shooting or removing alive Mexican gray wolves for their attacks on livestock. The Fish and Wildlife Service should revise its 2022 Mexican wolf 10(j) management rule to prohibit the removal of wolves as a consequence of wolves injuring or killing livestock.

Alternatively, the Service's revision of its management rule should prohibit wolf removals for conflicts with livestock that occur entirely on public lands, and only allow such removals after wolves prey on livestock on private lands when two conditions are fulfilled. The first is that the wolves had not previously scavenged on any livestock that died of non-wolf causes, because such scavenging on carrion is a primary precipitator of subsequent predation on livestock. The second condition is that the herd or flock from which one or more animals were preyed upon had a person or guard animals present at the time of the depredation who were nonetheless unable to deter the wolf or wolves.

Agencies that customarily work to "control" wolves should devote their freed-up resources to assisting ranchers in setting up resilient systems to prevent wolf attacks. Such government resources could, for example, help in erecting an electric fence with fladry to encircle a small pasture or a large holding area that pregnant cows would occupy during calving. Or the resources could pay for the purchase of horses or off-road vehicles to be used by range riders who would consistently monitor remote herds of cattle, ready to haze off wolves.



CONCLUSION: THE MEXICAN GRAY WOLF, IN GRAVE PERIL, CAN STILL BE RECOVERED

With 317 Mexican gray wolves counted in the wild in the Southwest in 2025,[44] pundits and agencies cheerfully anticipate the downlisting of the Mexican wolf to threatened status, followed by its delisting. However, the Endangered Species Act requires that all changes in species' listing statuses be based on the best available scientific information. In the case of the Mexican wolf, its abysmal genetic condition will preclude its downlisting in the near or midterm future – not to mention its complete delisting. Recovery is still possible, but it must be achieved not through denial, legerdemain and political shenanigans, but through dispassionately evaluating what has been tried thus far, what metrics are important to track, what results have been achieved, and what lessons must be learned.

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