Wildlife Society Bulletin 37(2):311–318; 2013; DOI: 10.1002/wsb.247

Original Article

Anthropogenic Impacts to the Recovery of the Mexican Gray Wolf With a Focus on Trapping-Related Incidents

TREY T. TURNBULL, *Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University, Las Cruces, NM 88003, USA*
JAMES W. CAIN, III,[1] *United States Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University, Las Cruces, NM 88003, USA*
GARY W. ROEMER, *Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University, Las Cruces, NM 88003, USA*

ABSTRACT Concerns regarding the potential negative impacts of regulated furbearer trapping to reintroduced Mexican gray wolves (*Canis lupus baileyi*), led to an executive order prohibiting trapping in the New Mexico, USA, portion of the Blue Range Wolf Recovery Area. This ban was to last for 6 months and required an evaluation of the risk posed to wolves by traps and snares legally permitted in New Mexico. We reviewed potential threats to wolves in the Blue Range Wolf Recovery Area, including threats associated with regulated furbearer trapping. One hundred Mexican gray wolf mortalities have been documented during the reintroduction effort (1998–2011). Of those mortalities with a known cause, >81% were human-caused resulting from illegal shooting ($n = 43$), vehicle collisions ($n = 14$), lethal removal by the United States Fish and Wildlife Service (USFWS; $n = 12$), non-project-related trapping ($n = 2$), project-related trapping ($n = 1$), and legal shooting by the public ($n = 1$). Ten wolves died due to unknown causes. The remaining 17 mortalities were a result of natural causes (e.g., starvation, disease). An additional 23 wolves were permanently, but non-lethally, removed from the wild by the USFWS. Of 13 trapping incidents in New Mexico that involved non-project trappers (i.e., trappers not associated with USFWS or U.S. Department of Agriculture-Wildlife Services), 7 incidents are known to have resulted in injuries to wolves: 2 wolves sustained injuries severe enough to result in leg amputations and 2 additional wolves died as a result of injuries sustained. Foothold traps with rubber-padded jaws and properly set snares may reduce trap-related injuries to Mexican gray wolves; however, impacts caused by trapping are overshadowed by other anthropogenic impacts (e.g., illegal shooting, non-lethal permanent removal, and vehicle collisions).

KEY WORDS *Canis lupus baileyi*, injury, Mexican gray wolf, snares, trap, trap injury, wolf.

Trapping furbearers for recreation or wildlife damage mitigation is a long-standing practice in the United States and other parts of the world, but has received increased scrutiny by the public in recent years because commonly used trapping methods have been perceived as being inhumane (Onderka et al. 1990, Andelt et al. 1999). These concerns have frequently led to increased regulation (but see Vantassel et al. 2010) and even total prohibition of common trapping methods in some jurisdictions (Muth et al. 2006), often as a result of ballot initiatives. Additionally, wildlife professionals often need to capture animals for research, and injured animals could bias results. A number of field projects have compared various traps and methods to find solutions that minimize trauma to target and non-target animals (e.g., Andelt et al. 1999, Frame and Meier 2007). Similar concerns about animal welfare and public perception of trapping led to the development of the "Best Management Practices" for furbearer trapping in the United States (International Association of Fish and Wildlife Agencies 1997). Given the potential for further restrictions being placed on trappers (e.g., potential bans on the importation of furs collected using certain methods; Proulx et al. 1994), evaluations of different trapping devices to address concerns about animal welfare and determine ways to potentially reduce injuries is likely to continue.

The potential impacts of regulated furbearer trapping on reintroduced Mexican gray wolves (*Canis lupus baileyi*) in New Mexico, USA, has become a concern of some sectors of the public, and trapping incidents involving Mexican gray wolves prompted Executive Order 2010-029 (Temporary Ban of Trapping in the Blue Range Wolf Recovery Area) on 28 July 2010. The Executive Order directed the New Mexico Department of Game and Fish to prohibit trapping in the New Mexico portion of the Blue Range Wolf Recovery Area for 6 months to conduct a study that would evaluate the risk posed to wolves by different types of traps and snares legally permitted in New Mexico. All previously legal methods to capture furbearers were prohibited from 1 November 2010 until 21 July 2011, except for residents trapping specifically to protect domesticated animals, or

Received: 24 October 2011; Accepted: 24 September 2012
Published: 5 February 2013

[1]*E-mail: jwcain@nmsu.edu*

trapping of species not regulated by the New Mexico Department of Game and Fish. Protected furbearers in New Mexico include raccoon (*Procyon lotor*), badger (*Taxidea taxus*), weasel (*Mustela* spp.), fox (*Vulpes* and *Urocyon* spp.), ringtail (*Bassariscus astutus*), bobcat (*Lynx rufus*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and nutria (*Myocastor coypus*), and their harvest is regulated by New Mexico Department of Game and Fish. Coyotes (*Canis latrans*) are an unprotected species in New Mexico and New Mexico Department of Game and Fish does not have authority to set bag limits, designate seasons, or methods of take (i.e., they are unregulated).

We reviewed scientific reports and other sources of information relevant to human-caused threats to wolves, including potential impacts from legally permitted traps and snares in the Blue Range Wolf Recovery Area. Our specific objectives were to 1) review known sources of mortality for Mexican gray wolves and collate all trapping incidents involving Mexican gray wolves; 2) evaluate the potential risk of permanent injury or death to Mexican gray wolves resulting from the use of different trapping devices currently allowed in New Mexico; and 3) identify trap and snare types, associated techniques, and potential modifications that may reduce risk of permanent injury or death to Mexican gray wolves by regulated furbearer trapping. Our review was primarily limited to trap types and snares legally permitted in New Mexico; a more comprehensive review can be found in Iossa et al. (2007).

METHODS

Sources of Mortality and Trapping Incidents for Mexican Gray Wolves

We obtained information on sources of mortality and trapping incidents for Mexican gray wolves by requesting them from the U.S. Fish and Wildlife Service (USFWS) and by reviewing annual reports (USFWS 2012*a*) and monthly updates on the Mexican Gray Wolf Recovery Program (USFWS 2012*b*). We reviewed information to determine the number of non-project trapping incidents (i.e., unrelated to the USFWS Mexican Gray Wolf Recovery Program) involving Mexican gray wolves, to quantify the injury status of trapped wolves and determine the fate of trapped wolves. We attempted to obtain information on the trap types (and any modifications thereof) and anchoring mechanisms used, and on species being targeted by non-project trappers. We also requested information on the known causes of mortality for all wolves during the recovery program.

Literature Review

To summarize the available data on injuries resulting from various foothold traps and snares, we used Google Scholar, Journal Storage (JSTOR), and Web of Science to search the scientific literature (both peer-reviewed literature and unpublished reports) for studies that compared trap-related injuries and examined trap-injury mitigation. Because the amount of time an animal spends in a trap has the potential to affect trap-related injuries (Proulx et al. 1994), we noted the trap-check intervals used in these studies. We used the following search terms: trap injury, foothold trap injury, leghold trap injury, foothold trap trauma, leghold trap trauma, wolf trap injury, furbearer trap injury, coyote trap injury, and bobcat trap injury. We entered search terms without quotations, so exact word order was not required of search results, and searches were the broadest offered by each site (i.e., not narrowed down by searching only keywords or only abstracts). Articles were deemed appropriate for review if they focused on trap injury mitigation and/or best practices associated with trapping wolf-like canids (e.g., members of the genus *Canis*) or trap sizes were consistent with those used for canids (e.g., bobcat studies). We further restricted the results of initial literature searches to only those trap types allowed by law in New Mexico and to regulated furbearer species and coyotes because the size of traps commonly used by trappers that target these species may present a risk of injury for Mexican gray wolves (NMDGF 2011). We did not include lethal, body-gripping traps in this review because they are not legally allowed in New Mexico in sizes large enough to pose a threat to large canids.

In addition, we searched the bibliographies of each pertinent source to find other relevant literature and we used the various search engines to locate articles that cited those we had already obtained. This process was repeated on each new source; we eventually reached a point when no new relevant material was discovered.

We also requested information on the average injury scores and sample sizes for each trap type recommended for use in the Best Management Practices for Trapping in the United States for wolves, coyotes, and bobcats (Association of Fish and Wildlife Agencies 2003, 2006*a*, *b*, *c*). The Best Management Practices resulted from extensive studies, with relatively large sample sizes, evaluating animal welfare, efficiency, species selectivity, practicality (e.g., use, cost), and user safety of a large number of trap types. Trauma scales used in the Best Management Practices followed guidelines presented in the International Organization for Standardization (1999). Trap types with an average cumulative injury score of ≤ 55 on one scale, or $\geq 70\%$ of a sample with "no injuries or mild–moderate trauma," met the Best Management Practices animal welfare criteria (Association of Fish and Wildlife Agencies 2006*a*). We requested data only pertaining to animal welfare.

RESULTS

Sources of Mortality and Trapping Incidents Involving Mexican Gray Wolves

Between 1998 and 2011, the USFWS documented 100 mortalities of Mexican gray wolves (USFWS 2012*c*). Forty-three wolves were illegally shot, 14 were hit by vehicles, 12 were lethally removed by the USFWS, 2 died from trap-related injuries resulting from traps set by non-project trappers, 1 was legally shot by the public, 1 wolf died from trap-related injury during the course of USFWS research operations, 10 died due to unknown causes, and 17 died of natural causes (e.g., starvation, disease). During this same period, 23 wolves were permanently (non-lethally) removed from the wild by the USFWS. Thus, over a 13-year period, 123 wolves were removed from the wild. At the end of 2011, the USFWS estimated the population size to be 58 wolves based on a minimum count (J. Oakleaf, USFWS, personal communication).

Fifteen captures involving 14 different wolves occurred with non-project trappers using foothold traps during the course of the reintroduction effort; female wolf 562 was captured twice. Thirteen of these incidents occurred in New Mexico, and 7 wolves incurred injuries as a result, 5 were apparently uninjured and the injury status is unknown but suspected for 1 wolf (see Table 1 in Turnbull et al. 2011 for more details on trapping incidents). Two wolves died as a result of injuries sustained, 2 sustained injuries severe enough to result in leg amputations, and 1 wolf had its toes amputated and the pad removed from its right foot. Of the 2 wolves that had their legs amputated, 1 was still alive as of July 2012 (M871; front leg amputated) and the other survived until at least January 2009 (m1039; J. Oakleaf, USFWS, unpublished data); the current fate of these wolves is unknown. The 3 remaining wolves injured in traps had varying fates: 1 wolf lived >2 years after being trapped but its current fate is unknown; 1 was killed by illegal shooting; and 1 survived until at least April 2011. Fifty-seven percent of the wolves that were injured by traps pulled the trap anchor loose from the ground, including 1 mortality (m1041) and 2 with severe injuries (wolf m1039, leg amputated by project veterinarians; wolf F562 toes and pad removed from right foot; J. Oakleaf, USFWS, unpublished data). All non-project trapping incidents in which wolves were apparently uninjured in New Mexico ($n = 5$) involved traps that remained anchored. The animals were subsequently released either by the trapper, by USFWS personnel, or were able to pull free of the trap themselves. Fates of the 5 uninjured wolves trapped in New Mexico included survival $\geq$1 year after the trapping incident with current fate unknown ($n = 1$), illegal shooting ($n = 1$), lethal removal by the USFWS ($n = 1$), mortality from an unknown cause >4 years after the trapping incident ($n = 1$) and, in the final case, mortality caused by intestinal blockage ($n = 1$, J. Oakleaf, unpublished data).

For most trapping incidents, we were unable to obtain specific information on the type of traps (e.g., rubber-padded jaw, offset jaw, laminated, and offset jaw), anchoring mechanisms, or species targeted by non-project trappers whose traps captured Mexican gray wolves. It seems, however, that all of the trapping incidents involved the use of foothold traps. We could not find any information suggesting that snares were involved in any trapping incident. At least 3 of the non-project trapping incidents in New Mexico involved traps specifically set for coyotes. It is unknown whether the traps involved in the other 10 incidents in New Mexico were set for coyotes or regulated furbearers; however, 2 of the trapping incidents resulting in injuries occurred outside the regulated furbearer trapping season (i.e., 1 Nov–31 Mar), which indicates that these traps were either set for coyotes or were illegally set out of season.

Literature Review

We reviewed 28 sources that evaluated injuries sustained by trapped furbearers; the majority were from either the *Wildlife Society Bulletin* ($n = 16$) or the *Journal of Wildlife Management* ($n = 8$). Two sources were unpublished progress reports from ongoing research on Best Management Practices for trapping wolves (White 2009, 2010), 1 was a final report describing Best Management Practices for trapping coyotes in the western United States (Association of Fish and Wildlife Agencies 2006*b*), and the final publication was from the proceedings of the Great Plains Wildlife Damage Control Workshop (Houben et al. 1993). In addition, we obtained average injury scores and sample sizes for each trap type recommended for use in the Best Management Practices for coyotes and bobcats through consultation with the authors (B. White, Association of Fish and Wildlife Agencies, personal communication).

Of the 28 sources, 6 included information on injuries sustained by gray wolves captured in several types of traps. Half of the sources ($n = 14$) reported testing of various types of traps and snares on coyotes. This testing was apparently due to the ready availability and relatively unprotected status of coyotes and the existence of government-supported

Table 1. Weighted mean injury score,[a] standard error (SE), and *n* for coyotes from studies[b] evaluating capture injuries resulting from the use of foothold traps and non-lethal cable snares.

Study variables	Conventional smooth-jaw[1,2,3]	Laminated and offset jaw[1]	Rubber-padded jaw[2,3,4]	Cable foot snare[3,4]	Non-lethal neck snare[4]
Mean	80.9	63.0	31.0	35.0	0.8
SE	38.2	8.0	19.8	21.9	NA
n	74	29	114	27	13

NA, not applicable.

[a] Weighted means were calculated using all data, whereas weighted SEs were calculated omitting data from Shivik et al. 2005), which did not report SEs. Numerical leg-injury scores are additive for each trapped individual, but injuries that were part of higher scoring injuries (i.e., tendon damage that was associated with a joint luxation, or cutaneous laceration caused by a compound fracture) were not double-counted. Point values are defined by Olsen et al. (1986) below. Severity of the injury increases with the severity index; that is, a larger index denotes a more severe injury. "Apparently normal = 0, Edematous swelling and hemorrhage = 5, Cutaneous laceration <2 cm = 5, Cutaneous laceration >2 cm = 10, Tendon and ligament laceration = 20, Joint subluxation = 30, Joint luxation = 50, Compression fraction above or below carpus or tarsus = 30, Simple fracture at or below carpus or tarsus = 50, 50, Compound fracture at or below carpus or tarsus = 75, Simple fracture above carpus or tarsus = 100, Compound fracture above carpus or tarsus = 200, Amputation = 400."

[b] Incorporates data from[1]Hubert et al. (1997), [2]Olsen et al. (1986), [3]Onderka et al. (1990), and [4]Shivik et al. (2005).

Table 2. Percentage of wolf injuries by severity class summarized from studies[a] evaluating wolf injuries caused by various types of foothold traps. In general, the severity of the injury increases with the severity class.

Injury severity class[b]	Conventional smooth-jaw[1]	Smooth-jaw,[1] offset (0.2 cm)	Toothed, offset jaw (1.8 cm)[1]	Toothed, offset jaw (0.7 cm)[1]	All unpadded jaw traps[c,2,3]	Rubber-padded jaw[2]
Class I	17	17	3	10	15	75
Class II	50	48	97	62	53	16
Class III	26	30		16	24	8
Class IV	7	5		12	8	1
N	269	116	40	129	663	96

[a] Incorporates data from [1]Kuehn et al. (1986), [2]Frame and Meier (2007), and [3]Van Ballenberghe (1984).

[b] Each captured animal was assigned to 1 of 4 injury categories as described by Van Ballenberghe (1984): Class I = "slight foot and/or leg edema with no lacerations and no evidence of broken bones or dislocated joints," Class II = "moderate edema with a skin laceration 2.5 cm or less long, bones and joints as in class I," Class III = "injuries–skin laceration >2.5 cm long with visible damage to underlying tissues, tendons intact, bone breakage limited to one phalanx or metacarpal," Class IV = "various combinations of deep, wide lacerations, severed tendons, broken metacarpals, broken radius and ulna bones, and joint dislocations of the leg."

[c] This category, incorporating all traps except the rubber-padded model used by Frame and Meier (2007), is included because Van Ballenberghe (1984) made 109 captures of wolves using 3 models of smooth-jawed and toothed, offset-jaw traps but did not have sufficiently large sample sizes with all devices to make a comparison and so made differentiation among these models. A foot snare was also tested, but sample size was insufficient for inclusion in the original work.

animal damage-control efforts, which were used as sources of data in several studies (Hubert et al. 1997, Darrow et al. 2009). Without the inclusion of data on trap-related injuries to coyotes, there would have been much less data from which to draw inferences. Other carnivore species involved in these evaluations included bobcats, lynx (*Lynx canadensis*), pumas (*Puma concolor*), red foxes (*Vulpes vulpes*), gray foxes (*Urocyon cinereoargenteus*), arctic foxes (*Vulpes lagopus*), and raccoons. Lastly, one article was a summary that compared the results of trapping injury studies conducted on several species, most of which were also included in this report (Andelt et al. 1999).

The 24 sources describing original field research on trap-related trauma used a variety of indices for evaluating the severity of injuries. The International Organization for Standardization procedures intended to standardize severity scores for capture-induced trauma did not exist until 1999 (Darrow et al. 2009), and 3 basic systems, and modifications thereof, were used in most of the studies. Olsen et al. (1986) developed a scale that was used in 4 studies, all conducted on coyotes (Table 1). A system devised by Van Ballenberghe (1984), and used in 3 studies involving wolves, relied on assigning trapped animals to 1 of 4 severity categories (Table 2). Lastly, 6 sources and the Best Management Practice studies (Association of Fish and Wildlife Agencies 2006*a*) incorporated a system based on the 1999 International Organization for Standardization standards; these studies involved wolves, coyotes, bobcats, and red foxes (Table 3 and references therein). The International Organization for Standardization-based system is described in detail by Darrow et al. (2009). Eleven of these 24 sources either did not use these systems, or did not represent their

Table 3. Weighted mean injury score[a] with standard error (where feasible), followed by sample size for red foxes, coyotes, and wolves from studies[b] evaluating capture injuries resulting from the use of foothold traps and non-lethal cable snares.

Species	Foot snare	Neck snare	Smooth-jaw, offset with stake	Smooth-jaw, offset with drag	Laminated, offset-jaw with stake	Laminated, offset-jaw with drag	Padded-jaw with stake
Red fox							
Mean	21.7	13.4					
SE	6.9	2.5					
n	27[1]	22[1]					
Coyote							
Mean	41.7	12.1	103.3		79.3		29.0
SE			12.0		7.9		
N	90[2,3]	40[3]	68[4]		59[4]		65[4]
Wolf							
Mean			47.1	53.4	23.0	51.0	
SE							
N			24[6]	35[6]	5[5]	10[5]	

[a] Injury scores were assigned on the basis of the 1999 International Organization for Standardization (ISO) procedures. Scores are cumulative. Note that in the case of Phillips et al. (1996), ISO procedures had not yet been published; however, the system used in that report is sufficiently comparable to include herein. The scores associated with each category of injury are described below, as in Darrow et al. (2009): 5 = "Edematous swelling, hemorrhage, or cutaneous abrasion," 10 = "Cutaneous laceration, minor periosteal abrasion or minor (below carpus or tarsus) subcutaneous soft-tissue maceration erosion," 25 = "Severance of minor tendon or ligament," 30 = "Major (above carpus or tarsus) subcutaneous soft-tissue maceration erosion, major periosteal abrasion, or permanent tooth fracture exposing pulp cavity," 50 = "Simple fracture at or below the carpus or tarsus," 100 = "Severance of major tendon or ligament or death."

[b] Incorporates data from [1]Muñoz-Igualada et al. (2008), [2]Darrow et al. (2009), [3]Shivik et al. (2000), [4]Phillips et al. (1996), [5]White (2010), and [6]White (2009).

data completely enough to be used in quantitative comparison.

Trap-check intervals were relatively consistent among the articles we reviewed. Other than the review article by Andelt et al. (1999), 81% ($n = 22$) of the studies had trap-check intervals ≤24 hours and 4 did not specifically state how frequently traps or snares were checked. Protocols for trap testing for the development of Best Management Practices require that traps be checked daily (Association of Fish and Wildlife Agencies 2006*a*). The study by Proulx et al. (1994) consisted of 2 trap lines: one was checked an average of every 1.4 days, and the other was checked every 8 days. There was a larger percentage of animals with high injury severity scores on the trap line checked at 8-day intervals (39.6% vs. 14.6%).

Foothold Traps

The most frequently tested type of trap was the smooth-jaw (i.e., without teeth), non-laminated foothold trap. These traps consistently resulted in more severe injuries to wolves (Van Ballenberghe 1984, Kuehn et al. 1986, Sahr and Knowlton 2000, Frame and Meier 2007), coyotes (Onderka et al. 1990; Phillips et al. 1996; Hubert et al. 1997; B. White, unpublished data), and other carnivores (Olsen et al. 1988, Kreeger et al. 1990, Earle et al. 2003; Tables 1–3) than did other types of traps and snares. Foothold traps with offset jaws (i.e., a space between the jaws when the trap is closed) did not typically result in lower injury scores than did non-offset, smooth-jaw traps (Tables 1–3), except for one model (which also featured laminated jaws [i.e., with both offset and laminated jaws; Houben et al. 1993]). Lamination consists of welding a thin piece of steel stock to the existing jaw, thereby making the jaw wider and increasing the area of contact between the jaw and the captured appendage. Foothold traps with laminated jaws resulted in somewhat lower injury scores than did the smooth jaw and offset jaw traps, but injury scores were still higher relative to other devices.

Traps with offset, toothed jaws were tested on wolves in 2 studies (Van Ballenberghe 1984, Kuehn et al. 1986), and they resulted in markedly reduced injuries compared with smooth-jawed traps, with no “moderate” or “severe” injuries reported for this trap type in one study (Kuehn et al. 1986; Table 2). These results were similar to those for traps with rubber-padded jaws.

Among the foothold traps evaluated, traps with rubber padding between the jaws consistently proved to be the most effective at mitigating injuries to all species of carnivores (Tables 1–3). In nearly all studies, there was a lower frequency of severe injury to captured animals compared with smooth-jawed foothold traps. Data from Best Management Practices were consistent with other studies for coyotes with traps, with rubber-padded jaws having lower severity scores than any other type of jaw trap (B. White, unpublished data).

Snares

Foot snares were tested in 9 published studies and in the Best Management Practice studies on bobcats and coyotes. Six of these studies involved coyotes. The other 5 studies were conducted on puma, lynx, bobcats, red foxes, and wolves. There was considerable variation in the severity of injuries sustained from the use of different foot-snare models when they were tested on coyotes. Onderka et al. (1990) tested 2 types, one of which produced injuries similar to that of a smooth-jawed foothold trap, with the other model causing injuries similar to a trap with rubber-padded jaws. Other authors found that various snares resulted in severity scores ranging from somewhat lower to slightly higher than those attributed to traps with rubber-padded jaws (Shivik et al. 2000, Darrow et al. 2009). Wolves (Van Ballenberghe 1984), red foxes (Muñoz-Igualada et al. 2008), and pumas (Logan et al. 1999) generally had low to extremely low frequencies of severe injury (Tables 1 and 3). Severity scores from Best Management Practice studies on coyotes and bobcats were lower than, or comparable to, severity scores from foothold traps with rubber-padded jaws (B. White, unpublished data).

Four studies were conducted using non-lethal cable neck snares: 2 on coyotes and 2 on red foxes (Table 3). Low to extremely low frequencies of serious injuries were reported using these devices and no animals were permanently harmed by these devices, except for 1 coyote killed by a malfunctioning device and some individuals that damaged their teeth (tooth chipped, 29–90%; tooth fractured, 0–67%) on the cable (Shivik et al. 2000, 2005; Muñoz-Igualada et al. 2008, 2010).

DISCUSSION

The current population of Mexican gray wolves, estimated at 58 individuals (J. Oakleaf, personal communication) is still well below the original U.S. Fish and Wildlife Service’s recovery goal of 100 free-ranging individuals (USFWS 1982). As of 31 December 2011, 100 wolf mortalities have been documented and an additional 23 animals have been permanently removed from the wild by the USFWS (USFWS 2012*a*). At least 81% of the documented mortalities with a known cause were caused by humans, with only 2% of all mortalities being caused by non-project trappers. Without estimates of the temporal variation in adult and juvenile vital rates, it is difficult to make inferences about the realized or potential growth of the reintroduced population; however, what is clear is that the permanent loss or removal of 123 wolves over the course of the reintroduction effort is not a positive contribution toward recovery. Further, this reduction in population size could have negated the positive contributions made by recent reintroductions of different genetic stock, which increased the genetic diversity of the reintroduced population and enhanced fitness through a reduction in inbreeding depression (Hedrick and Fredrickson 2010, Wayne and Hedrick 2011). It should be noted, however, that in some instances permanent removal of individual wolves might still be considered by managers to be the option most favorable to long-term recovery for social and economic reasons.

We were unable to obtain specific information on the type of traps or anchoring mechanisms used in most of the documented trapping incidents of Mexican gray wolves, nor were we able to determine the length of time that wolves spent in the traps. The majority of injuries, including the most severe ones, occurred during trapping incidents in which the trap anchors were pulled loose, indicating that the method of anchoring was insufficient to hold a wolf until it could be released (Turnbull et al. 2011). Conversely, most of the uninjured wolves were caught in traps in which the anchoring mechanism remained secure. General recommendations for trappers suggest that the anchoring system should be sufficient to "hold the largest furbearer that might be captured" (Association of Fish and Wildlife Agencies 2006*a*: 9). Anchoring systems sufficient to hold coyotes or regulated furbearers may not be strong enough to hold Mexican gray wolves, potentially leading to more severe injuries to wolves if the trap anchor is pulled loose.

Our review of the literature on injuries induced by different traps and trapping methods echoes previous reviews. Traps with rubber-padded jaws generally caused less severe injury to all species captured than did other types of foothold traps (Olsen et al. 1988, Andelt et al. 1999, Frame and Meier 2007). The various cable foot snares evaluated, although somewhat inconsistent in performance, generally resulted in lower severity scores than did smooth-jawed foothold traps, and some even produced lower injury scores than foothold traps with rubber-padded jaws, at least when the foot snares were properly anchored (Onderka et al. 1990, Mowat et al. 1994, Logan et al. 1999, Shivik et al. 2005, Muñoz-Igualada et al. 2010). Additionally, in one study conducted on lynx under extremely cold conditions, cable foot snares never caused limb freezing, while foothold traps with rubber-padded jaws often did. Maintaining circulation in the restrained limb is potentially an important point for trappers in areas with severe winters (Mowat et al. 1994). Smooth-jawed foothold traps, even with laminated or offset jaws, generally presented a higher potential for injury to all species targeted in the studies. Wolves were no exception, with high percentages of those caught in these traps sustaining injuries, including fractures, major cutaneous lacerations, and tendon damage (Sahr and Knowlton 2000, Frame and Meier 2007). Although many of the published studies provided details on the trap sizes, chains, swivels, stakes, and drags used, it is worth noting that comparisons of these modifications and how they may influence the severity of injuries were largely lacking.

In addition to trap jaw type and anchoring mechanisms used, the amount of time an animal is restrained in a trap can influence the occurrence and severity of an injury. Daily trap checks were the most common trap-check interval in the published studies we reviewed and may reduce the extent of injuries to trapped animals than less frequent trap-check intervals (Proulx et al. 1994, Andelt et al. 1999). Most states require that foothold traps be checked every 24 hours, or daily. Some states have less frequent trap-check requirements, or less frequent requirements for restraining snares, or less stringent requirements for predators and unregulated species (e.g., coyote; Andelt et al. 1999, Association of Fish and Wildlife Agencies 2007, Gebhardt et al. 2009). The New Mexico Department of Game and Fish requires that all traps set for protected furbearers have to be visually inspected every calendar day (NMDGF 2011). For most trappers, checking traps more than once in a 24-hour period is not logistically feasible. The trap-check requirements in New Mexico do not specifically include traps set for coyotes; however, any trap that may reasonably be expected to capture a protected furbearer is subject to the same restriction, except in the case of a trap or snare set by New Mexico Department of Game and Fish personnel or their designated agents acting in their official capacity (e.g., U.S. Department of Agriculture-Animal and Plant Health Inspection Service-Wildlife Services; New Mexico Administrative Code 19.32.2).

Human-induced mortality has been shown to be an important factor influencing wolf population dynamics (Creel and Rotella 2010, Murray et al. 2010, Gude et al. 2012). In the Blue Range Wolf Recovery Area, the percentage of wolves that were killed or injured as a direct result of trapping incidents is far lower than the percentage that were killed through illegal shooting, vehicle collision, lethal control, or non-lethal but permanent removal from the population. Nevertheless, the loss of wolves from reproductively successful packs, or the mortality of a wolf whose genes increase the fitness of the reintroduced population by reducing inbreeding depression could have bearing on recovery (Vilá et al. 2003, Wayne and Hedrick 2011). Human-induced mortality has most likely impeded the recovery of the Mexican gray wolf, and we suggest that parties concerned with reestablishing this subspecies focus on the sources of human-caused mortality that are of greatest conservation concern.

MANAGEMENT IMPLICATIONS

Currently, trapping-related mortalities of Mexican gray wolves are relatively few in comparison to those resulting from illegal shooting, vehicle collisions, and lethal control. If trapping-related injuries and mortalities were to increase for Mexican gray wolves in the future, certain regulatory changes may warrant further consideration to mitigate trapping-related impacts without implementing a total ban on trapping in the Mexican gray wolf recovery area. If injury mitigation were a goal, one way to reduce severity of injury to trapped Mexican gray wolves would be to use foothold traps with rubber-padded jaws or properly set foot snares. These 2 trap types consistently yielded less severe injuries than other types of traps. Foothold traps with laminated and offset jaws generally produced lower injury severity scores than did unmodified, smooth-jawed traps, but consistently produced injury severity scores that were higher than those produced by rubber-padded jaw traps or cable foot snares. Because the majority of wolves that were injured involved traps that were pulled loose from their anchoring mechanism, use of anchoring systems that reduce the likelihood of traps being pulled loose (e.g., double-staking or fastening traps to trees or other immovable objects) and use of short chains or cables to prevent lunging and rolling-induced injuries may also be warranted.

ACKNOWLEDGMENTS

New Mexico Department of Game and Fish and the New Mexico State University Agricultural Experiment Station provided funding. We thank J. Oakleaf of the USFWS and B. White of Association of Fish and Wildlife Agencies for providing us with unpublished data. Reviews by T. L. Hiller, M. J. Kauffman, P. R. Krausman, and an anonymous reviewer improved an earlier draft of this manuscript. The use of trade names or products does not constitute endorsement by the U.S. Government.

LITERATURE CITED

Andelt, W. F., R. L. Phillips, R. H. Schmidt, and R. B. Gill. 1999. Trapping furbearers: an overview of the biological and social issues surrounding a public policy controversy. Wildlife Society Bulletin 27:53–64.

Association of Fish and Wildlife Agencies. 2003. Best management practices for trapping coyotes in the eastern United States. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Association of Fish and Wildlife Agencies. 2006*a*. Best management practices for trapping in the United States: introduction. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Association of Fish and Wildlife Agencies. 2006*b*. Best management practices for trapping coyotes in the western United States. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Association of Fish and Wildlife Agencies. 2006*c*. Best management practices for trapping bobcats in the United States. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Association of Fish and Wildlife Agencies. 2007. Summary of trapping regulations for fur harvesting in the United States. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Creel S., and J. J. Rotella. 2010. Meta-analysis of relationships between human offtake, total mortality and population dynamics of gray wolves (*Canis lupus*). PLoS ONE 5(9):e12918. DOI: 10.1371/journal.pone.0012918

Darrow, P. A., R. T. Skirpstunas, S. W. Carlson, and J. A. Shivik. 2009. Comparison of injuries to coyote from 3 types of cable foot-restraints. Journal of Wildlife Management 73:1441–1444.

Earle, R. D., D. M. Lunning, V. R. Tuovila, and J. A. Shivik. 2003. Evaluating injury mitigation and performance of #3 Victor Soft Catch (R) traps to restrain bobcats. Wildlife Society Bulletin 31:617–629.

Frame P. F., and T. J. Meier. 2007. Field-assessed injury to wolves captured in rubber-padded traps. Journal of Wildlife Management 71:2074–2076.

Gebhardt, K., S. A. Shwiff, B. R. Leland, D. R. Hatchett, and M. J. Bodenchuk. 2009. Methodology to estimate cost savings associated with the use of trap monitor systems by wildlife services. Wildlife Damage Management Conference Proceedings 13:132–136.

Gude, J. A., M. S. Mitchell, R. E. Russell, C. A. Sime, E. E. Bangs, L. D. Mech, and R. R. Ream. 2012. Wolf population dynamics in the U.S. are affected by recruitment and human-caused mortality. Journal of Wildlife Management 76:108–118.

Hedrick P. W., and R. Fredrickson. 2010. Genetic rescue guidelines with examples from Mexican wolves and Florida panthers. Conservation Genetics 11:615–626.

Houben, J. M., M. Holland, S. W. Jack, and C. R. Boyle. 1993. An evaluation of laminated offset jawed traps for reducing injuries to coyotes. Great Plains Wildlife Damage Control Workshop Proceedings 340:148–153.

Hubert, G. F., L. L. Hungerford, and R. D. Bluett. 1997. Injuries to coyotes captured in modified foothold traps. Wildlife Society Bulletin 25:858–863.

International Association of Fish and Wildlife Agencies. 1997. Improving animal welfare in U.S. trapping programs: process recommendations and summaries of existing data. International Association of Fish and Wildlife Agencies, Washington, D.C., USA.

International Organization for Standardization. 1999. Animal (mammal) traps. Part 5: methods for testing restraining traps. International Standard ISO/DIS 10990-5. International Organization for Standardization, Geneva, Switzerland.

Iossa, G., C. D. Soulsbury, and S. Harris. 2007. Mammal trapping: a review of animal welfare standards of killing and restraining traps. Animal Welfare 16:335–352.

Kreeger, T. J., P. J. White, U. S. Seal, and J. R. Tester. 1990. Pathological responses of red foxes to foothold traps. Journal of Wildlife Management 54:147–160.

Kuehn, D. W., T. K. Fuller, L. D. Mech, W. J. Paul, S. H. Fritts, and W. E. Berg. 1986. Trap-related injuries to gray wolves in Minnesota. Journal of Wildlife Management 50:90–91.

Logan, K. A., L. L. Sweanor, J. F. Smith, and M. G. Hornocker. 1999. Capturing pumas with foot-hold snares. Wildlife Society Bulletin 27:201–208.

Mowat, G., B. G. Slough, and R. Rivard. 1994. A comparison of 3 live capturing devices for lynx: capture efficiency and injuries. Wildlife Society Bulletin 22:644–650.

Muñoz-Igualada, J., J. A. Shivik, F. G. Dominguez, L. M. Gonzalez, A. A. Moreno, M. F. Olalla, and C. A. Garcia. 2010. Traditional and new cable restraint systems to capture fox in central Spain. Journal of Wildlife Management 74:181–187.

Muñoz-Igualada, J., J. A. Shivik, F. G. Dominguez, J. Lara, and L. M. Gonzalez. 2008. Evaluation of cage-traps and cable restraint devices to capture red foxes is Spain. Journal of Wildlife Management 72:830–836.

Murray, D. L., D. W. Smith, E. E. Bangs, C. Mack, J. K. Oakleaf, J. Fontaine, D. Boyd, M. Jimenez, C. Niemeyer, T. J. Meier, D. Stahler, J. Holyan, and V. J. Asher. 2010. Death from anthropogenic causes is partially compensatory in recovering wolf populations. Biological Conservation 143:2514–2524.

Muth, R. M., R. R. Zwick, M. E. Mather, J. F. Organ, J. J. Daigle, and S. A. Jonker. 2006. Unnecessary source of pain and suffering or necessary management tool: attitudes of conservation professionals toward outlawing leghold traps. Wildlife Society Bulletin 34:706–715.

New Mexico Department of Game and Fish [NMDGF]. 2011. Big game and trapper rules and information. New Mexico Department of Game and Fish, Santa Fe, USA.

Olsen, G. H., S. B. Linhart, R. A. Holmes, G. J. Dasch, and C. B. Male. 1986. Injuries to coyotes caught in padded and unpadded steel foothold traps. Wildlife Society Bulletin 14:219–223.

Olsen, G. H., R. G. Linscombe, V. L. Wright, and Robert. A. Holmes. 1988. Reducing injuries to terrestrial furbearers by using padded foothold traps. Wildlife Society Bulletin 16:303–307.

Onderka, D. K., D. L. Skinner, and A. W. Todd. 1990. Injuries to coyotes and other species caused by 4 models of footholding devices. Wildlife Society Bulletin 18:175–182.

Phillips, R. L., K. S. Gruver, and E. S. Williams. 1996. Leg injuries to coyotes captured in 3 types of foothold traps. Wildlife Society Bulletin 24:260–263.

Proulx, G., I. M. Pawlina, D. K. Onderka, M. J. Badry, and K. Seidel. 1994. Field evaluation of the number 1½ steel-jawed leghold and the Sauvageau 2001-8 traps to humanely capture arctic fox. Wildlife Society Bulletin 22:179–183.

Sahr D. P., and F. F. Knowlton. 2000. Evaluation of tranquilizer trap devices (TTDs) for foothold traps used to capture gray wolves. Wildlife Society Bulletin 28:597–605.

Shivik, J. A., K. S. Gruver, and T. J. DiLiberto. 2000. Preliminary evaluation of new cable restraints to capture coyotes. Wildlife Society Bulletin 28:606–613.

Shivik, J. A., D. J. Martin, M. J. Pipas, J. Turnan, and T. J. DiLiberto. 2005. Initial comparison: jaws, cables, and cage-traps to capture coyotes. Wildlife Society Bulletin 33:1375–1383.

Turnbull, T. T., J. W. Cain, III, and G. R. Roemer. 2011. Evaluating trapping techniques to reduce potential for injury to Mexican wolves. U.S. Geological Survey Open File Report 2011-1190, Reston, Virginia, USA.

U.S. Fish and Wildlife Service [USFWS]. 1982. Mexican wolf recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico, USA.

U.S. Fish and Wildlife Service [USFWS]. 2012*a*. Annual reports on the Mexican gray wolf recovery program. <http://www.fws.gov/southwest/es/mexicanwolf/documents.cfm>. Accessed 25 Jul 2012.

U.S. Fish and Wildlife Service [USFWS]. 2012*b*. Blue Range Wolf Reintroduction Area (BRWRA) monthly project updates. <http://www.fws.gov/southwest/es/mexicanwolf/BRWRP_notes.cfm>. Accessed 25 Jul 2012.

U.S. Fish and Wildlife Service [USFWS]. 2012*c*. Mexican wolf population statistics. <http://www.fws.gov/southwest/es/mexicanwolf/MWPS.cfm>. Accessed 25 Jul 2012.

Van Ballenberghe, V. 1984. Injuries to wolves sustained during live-capture. Journal of Wildlife Management 48:1425–1429.

Vantassel, S. M., T. L. Hiller, K. D. J. Powell, and S. E. Hygnstrom. 2010. Using advancements in cable-trapping to overcome barriers to furbearer management in the United States. Journal of Wildlife Management 74:934–939.

Wayne R., and P. Hedrick. 2011. Genetics and wolf conservation in the American West: lessons and challenges. Journal of Heredity 107: 16–19.

Vilá, C., A.-K. Sundqvist, Ä. Flagstad, J. Seddon, S. Bjönerfeldt, I. Kojola, A. Casulli, H. Sand, P. Wabakken, and H. Ellegren. 2003. Rescue of a severely bottlenecked wolf (*Canis lupus*) population by a single immigrant. Proceedings of the Royal Society B 270:91–97.

White, B. 2009. Testing restraining traps for the development of best management practices for trapping gray wolf in the United States. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

White, B. 2010. Testing restraining traps for the development of best management practices for trapping gray wolf in the United States. Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Associate Editor: Hiller.