Review of Social and Biological Science Relevant to Wolf Management in Michigan

A Reference Document for the
Michigan Department of Natural Resources

Michigan Department of Natural Resources
Wildlife Division Report No. 3707
September 2022

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Recommended citation:

Michigan Department of Natural Resources. 2022. Review of Social and Biological Science Relevant to Wolf Management in Michigan. Wildlife Division Report No. 3707. Michigan Department of Natural Resources, Lansing, MI. 159 pp.

List of Abbreviations

DNR	Michigan Department of Natural Resources
LP	Lower Peninsula
NLP	Northern Lower Peninsula
SLP	Southern Lower Peninsula
UP	Upper Peninsula
MDARD	Michigan Department of Agriculture and Rural Development
MSU	Michigan State University
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
NRC	Michigan Natural Resources Commission
NREPA	Natural Resources and Environmental Protection Act

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Introduction

This document provides a review of the current state of scientific knowledge pertaining to wolves, wolf-related issues, and wolf-management options in Michigan. It summarizes the best available biological and social science relevant to these topics, identifying where significant uncertainty remains, as appropriate. Information presented herein was obtained from published scientific literature, agency and university reports, unpublished agency data, and personal communication with wolf experts. Results of a public-attitude survey conducted by Michigan State University in 2021 (Riley et al. 2022) are presented throughout this document.

This document has been prepared for use by the Michigan Department of Natural Resources as it updates its Wolf Management Plan. Consideration and integration of the scientific information it contains will be critical to the success of managing wolves in the State, because the Michigan Department of Natural Resources is required to use sound science when making decisions about wildlife management. Science allows managers to predict consequences (both social and biological) of management actions; it is thus a tool of primary importance for identifying those actions which would most effectively achieve specific wildlife management goals.

Scientific data or methods, however, do not establish goals or objectives for wildlife management. Those are determined by stakeholders internal and external to the Department of Natural Resources within a social context where values, beliefs, and preferences must be considered. Therefore, the decision-making process is biological and ecological science based, but it also depends heavily on insights from social science and negotiation to integrate stakeholder interests inherent in wolf management issues. That social negotiation constitutes the 'socio-political' portion of decision making[1]. It is this portion of decision-making, not science, which assigns priorities to the values held by diverse stakeholders about particular management approaches. Science can help predict the biological and social consequences of controlling or not controlling wolf population size, for example, but a socio-political process determines whether the consequences of either option are acceptable to society.

Science, whether biological, ecological, or social, provides the best possible information regarding the probable consequences of certain management decisions, but it seldom eliminates all uncertainty. In some cases, remaining uncertainty may be small and of little concern; in others, it may be considerable and pose important risks. Individuals responsible for formulating policy and management plans who determine how to address risks posed by remaining uncertainty are more likely to achieve desired outcomes.

Therefore, this document does not provide answers to questions of how wolves should be managed in Michigan (those decisions must be made within a socio-political context which considers value conflicts and acceptability of risks associated with uncertainty). Rather, this document facilitates understanding

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[1] The term is preferred over 'political' which technically refers to the processes of government, and which often carries some negative connotations. The wolf management planning process is truly an integration of social and political forces, and the term seems appropriate.

of the potential consequences of certain management approaches and aims to inform policy and management decisions with the best available science.

Chapter 1 Wolf Biology and Status

Taxonomy

The recovery plan for the eastern timber wolf (*Canis lupus lycaon*) (U.S. Fish and Wildlife Service 1978, 1992) was written under the assumption that wolves currently and historically inhabiting the northeastern United States were a subspecies of the Eurasian-evolved gray wolf (*C. lupus*). Since then, the taxonomic classification of wolves in the eastern part of the United States, including the Great Lakes region, has been the subject of numerous studies with differing results (e.g., Nowak 1995, Wayne et al. 1995, Wilson et al. 2000, Kyle et al. 2006, Leonard and Wayne 2008, Koblmuller et al. 2009, vonHoldt et al. 2011, Rutledge et al. 2012, Rutledge et al. 2015, vonHoldt et al. 2016). There are two primary hypotheses on the origin of wolves in the Great Lakes region: 1) they represent a unique population or ecotype of gray wolf, now mostly extinct (Leonard and Wayne 2008, Koblmüller 2009), or 2) they represent a unique admixed population resulting from historic gray wolf and eastern wolf (*C. lycaon*) hybridization, where both gray and eastern wolves may have inhabited the region (Wheeldon and White 2009). While there is no broad consensus on their origin, current analyses demonstrate contemporary wolves from the Great Lakes region are genetically distinct from other gray wolf populations and admixed, with ancestry from gray wolves, eastern wolves, and coyotes (*C. latrans*) (Rutledge et al. 2015, Heppenheimer et al. 2018). Genetic analysis of wolves from the Great Lakes region found no current evidence of coyote mtDNA or Y-chromosome introgression (or putatively minimal) (Wheeldon et al. 2010). Eastern wolves now persist almost exclusively in Algonquin Provincial Park, Ontario, but likely served as the conduit of gene flow between gray wolves and coyotes. Wolves in the Great Lakes region may also be smaller than the western gray wolf (Wilson et al. 2000), suggesting genetic ancestry may impact morphology of wolves in the region.

Few genetic studies of wolves have been conducted in the Upper Peninsula (mainland); thus, the genetic health and ancestry across the state is not well characterized. When Michigan's wolf population was nearly, if not completely extirpated by 1970 (Hendrickson and Robinson 1973), sporadic founding events led to recolonization. Yet it is unknown if the population growth associated with wolves in Michigan is from many founding events from the early 1970s to present or a limited number of founding events, which has genetic implications, such as reduced genetic diversity and higher inbreeding. From estimating inbreeding coefficients of wolves in the Great Lakes region using genomic tools, we found some evidence of inbreeding in Michigan and Wisconsin wolves compared to Minnesota and Ontario, (K. Brzeski, Michigan Technological University, unpublished data). Serial founding events could also impact the genetic ancestry of the population, depending on the origin of colonizing wolves. The body mass of wolves from the Upper Peninsula is as large as or larger than wolves found in Minnesota (Theberge and Theberge 2004; D. Beyer, Michigan DNR, unpublished data), suggesting they may have more gray wolf ancestry than eastern wolf or coyote. Further research will help determine the full genetic health and ancestral makeup of Michigan's wolf population.

Description

The wolf is Michigan's largest member of the Canidae, or dog family. Other native Michigan canids are the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and gray fox (*Urocyon cinereoargenteus*). Wolves are larger than coyotes, with body dimensions exceeding those of a fully grown German shepherd or Alaskan malamute. In Michigan, weights of adult gray wolves range from 58 to 112 pounds (26–51kg), with males (average: 87 lbs; 39 kg) weighing slightly more than females (average: 76 lbs; 34 kg). Wolves are approximately 6 feet (1.8 m) long from the nose to the end of the tail. Adults stand 30–34 inches (75–85 cm) tall at the shoulder. The feet of wolves are large, with tracks measuring 3.5–4 inches (9–10 cm) wide and 4.5–5 inches (11–13 cm) long. Wolves have cheek tufts that make their faces appear wide and their heads large. Their tails are bushy and straight, not curled like most dogs.

Wolves are predators well-adapted to cold and temperate climates. The dense underfur in their winter coats is protected by guard hairs that may be up to 6 inches (15 cm) long over the shoulder. Their skeletal and muscular structures make them well-adapted to travel. They have tremendous stamina and often spend 8–10 hours per day on the move, primarily during early morning and evening.

Social Structure and Behavior

The life of a typical individual wolf is centered on a distinct family unit or pack (Baker 1983). The basic functional unit of a pack is the dominant breeding pair, often called the 'alpha' pair (Mech and Boitani 2003a). A pack is typically comprised of these two dominant animals, their pups from the current year, offspring from previous litters, and occasionally other wolves that may or may not be related to the alpha pair (Young and Goldman 1944, Stenlund 1955, Mech 1966). Wolves where once thought to follow a linear dominance hierarchy which occurs within the pack, where each member occupies a rank or position (Mech 1970). These early studies of social dynamics were conducted on captive wolves and subsequent research when observing wild wolf packs in a wider range of contexts found that all wolf packs do not fit a linear dominance hierarchy (Mech 1999, Mech and Boitani 2003a). Alphas can change as the health and environment of an individual changes within the pack (Packard 2003). However, the alpha male and female are normally the only animals that breed, but there are exceptions (Ballard et al. 1987).

Based on ten studies, the average pack size of wolves which prey primarily on deer (*Odocoileus* spp.) is 5.7 (Fuller et al. 2003). Pack sizes in Montana with more diverse and larger ungulate prey was similar, averaging 5.9 overall and ranging from 4.9 to 7.0 (Sells et al. 2022). Pack sizes in Minnesota have ranged from 3.6 to 5.6 individuals (Erb and Benson 2004, Erb and Humpal 2021). Average pack size in Michigan in winter during 2000-2020 ranged from 3.2 to 5.3 (B. Roell, Michigan DNR, unpublished data; Table 1-1).

Table 1-1. Summary of wolf pack composition data collected during the winter wolf population surveys in the Upper Peninsula of Michigan, 2000–2020.

Year	*n* Packs[a]	*n* Pairs	*n* Loners	$\bar{x}$ Pack size	Range	95% C.L[b]
2000	63	27	14	3.2	2–7	N/A
2001	70	33	5	3.5	2–11	N/A
2002	63	17	8	4.3	2–10	N/A
2003	68	18	11	4.6	2–14	N/A
2004	77	24	6	4.6	2–12	N/A

Year	*n* Packs[a]	*n* Pairs	*n* Loners	$\bar{x}$ Pack size	Range	95% C.L[b]
2005	87	24	6	4.6	2–13	N/A
2006	91	22	11	4.6	2-17	N/A
2007	103	21	5	4.9	2-12	36
2008	115	27	11	4.4	2-15	146
2009	108	20	4	5.3	2-18	39
2010	109	21	3	5.1	2-16	53
2011	131	27	4	5.2	2-14	63
2013	126	24	3	5.2	2-12	56
2014	125	23	3	5.1	2-12	42
2016	124	23	4	5.0	2-11	50
2018	139	24	1	4.8	2-11	69
2020	143	16	6	4.8	2-12	75

[a]A pack is defined as two or more animals. The number of packs includes the pairs that are listed in the second column.

[b]Starting in 2007 the population estimate moved to a monitoring program based on geographic stratification which samples approximately 60% of the U.P. during a survey year.

Wolves establish and maintain territories (Ballard et al. 1987, Fuller 1989, Mech and Boitani 2003a). Howling between packs and scent-marking along territory edges are the principal means of spacing in wild wolf populations. Territory size can vary greatly and depends on the density of wolves and the density and distribution of prey. Estimates of territory size also vary depending on the field and analytical methods used (e.g., number of telemetry relocations; Fritts and Mech 1981, Bekoff and Mech 1984, Mech et al. 1998; see also Kie et al. 2010, Noonan et al. 2019).

Sizes of individual wolf pack territories in the Upper Peninsula of Michigan have ranged from 22 mi^2 to 128 mi^2 (56–331 km^2) and in 2004, averaged 65 mi^2 (169 km^2) when using VHF telemetry data (Huntzinger et al. 2005). Advancements in collar GPS technology has greatly increased relocation telemetry data which has provided a more accurate calculation of territory sizes. Current estimates using GPS data suggest the average territory is 98 mi^2 (259 km^2) in the Upper Peninsula of Michigan (Michigan DNR, unpublished data).

Reproduction

Some captive wolves were capable of breeding at 9–10 months of age (Medjo and Mech 1976), but wild wolves typically reach sexual maturity at 22 months of age (Mech 1970, Fuller 1989). Mating takes place in February, dens are dug in March, and pups are born in middle to late April (Peterson 1977, Fuller 1989).

Litter sizes can vary, but usually number four to six pups (Mech 1970, Ferreras-Colino et al. 2021), but can be greater based on wolf density, with lower density populations having larger litter sizes (Sidorovich et al. 2007). Pups are born with their eyes and ears closed and lack the ability to properly thermoregulate their body temperature (Mech 1970). Pups' eyes open when they are between 11 and 15 days old (Rutter and Pimlott 1968, Mech 1970). When they are approximately 3 weeks old, pups emerge from their dens and can be found playing nearby (Young and Goldman 1944). Pups are weaned at approximately 9 weeks and moved to a rendezvous site. By the time pups are 4–6 months old, they are nearly as large as an adult wolf (Carbyn 1987).

Causes of Mortality and Survival Rates

Annual mortality of wolves can fluctuate widely from year to year. Up to 60% of pups may die from disease and malnutrition during their first 6 months of life. Mortality rates approximate 45% from 6 months to 1 year, and 20% between years 1 and 2 (Pimlott et al. 1969, Mech 1970, Mech and Frenzel 1971, Van Ballenberghe et al. 1975, Fritts and Mech 1981). Reported wolf survival rates in the United States often range from about 75-79% (Adams et al. 2008, Wydeven et al. 2009, Smith et al. 2010, Cubaynes et al. 2014). Annual wolf survival in the Upper Peninsula of Michigan was 75% during 1994-2013 (O'Neil 2017). Human-caused mortality was the dominant source of mortality for Michigan wolves, representing 17% annually and increasing with wolf density (O'Neil 2017). Human-caused mortality includes vehicle strikes and illegal shooting. Annual adult wolf survival in Wisconsin from 1979 to 2013 was 76%, with dominant mortality sources including illegal killing (9.4%), natural and unknown causes (9.5%), and other human-caused mortality (e.g., hunting, vehicle collisions, lethal control; 5.1%) (Stenglein et al. 2018). Stenglein et al. (2018) noted partial compensation in both natural- and human-caused mortality during recolonization once the population saturated available habitat. Average annual adult survival in the Superior National Forest, Minnesota, was 78% (Barber-Meyer et al. 2021). Adults may live up to 13 years, but most die much sooner (D. Mech, personal communication, 1996). No animal habitually preys on the wolf, but pups may occasionally be taken by a bear or other predator. Both moose (*Alces alces*) and deer have injured or killed wolves (Nelson and Mech 1985, Mech and Nelson 1989). Other natural mortality factors include accidents, malnutrition, starvation, parasites, diseases, and fatal encounters during territorial disputes between packs.

Causes of mortality are often at least partially compensatory (Mech 2001, Fuller et al. 2003, Borg et al. 2015, O'Neil 2017, Stenglein et al. 2018). For example, human-induced mortality can sometimes replace mortality that would otherwise occur due to natural factors, such as starvation, disease or intraspecific aggression (Fuller et al. 2003, Rutledge et al. 2010, O'Neil 2017). Studies in Minnesota and Denali National Park, Alaska, where wolves are not harvested, reported that approximately 10% of the wolves in each population were killed by other wolves (Mech 1977a, Mech et al. 1998). By contrast, in areas of Alaska where wolves were legally harvested, mortality due to intraspecific aggression was much lower (Peterson et al. 1984, Ballard et al. 1987, Ballard et al. 1997). This comparison supports the conclusion that mortality caused by other wolves is compensatory to that caused by harvesting (Mech 2001). However, whether mortality sources are compensatory or additive to other sources appears more complex and likely context dependent. For example, Adams et al. (2008) analyzed North American wolf populations and found that wolf population trends were not associated with levels of human-caused mortality <29%, due primarily to local dispersal, emigration and immigration. In contrast, in a meta-analysis using data from 21 wolf populations in North America, Creel and Rotella (2010) suggested human offtake could be additive or result in super-additive increases in total wolf mortality. However, Creel and Rotella (2010) also concluded that wolves can be harvested sustainably within limits. In a reanalysis of these same data considering data limitations and improved modeling, Gude et al. (2012) determined that the predictions for declining wolf populations reported by Creel and Rotella (2010) were not supported.

The overall effects of poaching on wolf populations are difficult to quantify. Poaching can be an important source of mortality for wolves (e.g., Finland; Suutarinen and Kojola 2017) and has been reported to reduce wolf population growth (Liberg et al. 2012). In an analysis of 21 studies that monitored the fates of 3,564 wolves with 1,442 reported mortalities, 23% of mortalities were from illegal harvest and 16% from legal harvest (Hill et al. 2022). Santiago-Avila et al. (2020) reported increased prevalence of unreported poaching of wolves in Wisconsin during periods of policy change providing increased ability to use lethal wolf control in defense of human property or safety. Treves et al. (2021) reported increases in undocumented poaching coincided with a legal wolf hunt in Wisconsin. However, it is not possible to quantify poaching that is not reported or otherwise documented and approaches attempting this have been previously refuted (e.g., Olson et al. 2016). Documented poaching of wolves in Wisconsin reportedly increased during periods of snow cover and dog training and hunting seasons for other large mammals relative to the period 15 April-30 June (Santiago-Aviala and Treves 2022).

In Michigan, illegal killing of wolves accounted for 39% of radio-collared wolf mortality during 2010–2020 (Table 1-2). Wolves with radio-collars could be more or less likely to be killed illegally because radio-collars can be visible when wolves are sighted. If radio-collared wolves are less likely to be killed, then the actual proportion of mortality due to illegal activity could be higher. Almost 61% of the radio-collared wolf mortality is directly related to humans.

Table 1-2. Causes of mortality for radio-collared wolves in the Upper Peninsula of Michigan for bioyears 2010–2020.

Mortality factors	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Totals	Percent
Vehicle	0	1	0	1	0	0	1	0	0	1	0	4	4
Illegal Kill (includes presumed)	4	6	2	5	2	1	3	2	6	6	2	39	43
Natural[b]	4	3	2	0	4	4	5	1	0	2	1	26	29
Other Human	0	0	0	0	0	1	1	1	0	1	0	4	4
Unknown	2	0	3	0	2	3	1	1	0	1	0	13	14

Mortality factors	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Totals	Percent
Legal Harvest	1	0	0	0	1	0	2	0	0	0	0	4	4
Totals	11	10	7	6	9	9	13	5	6	11	3	90	100

[a]Bioyear is defined as April 15th to April 14th

[b]Natural causes include intraspecific strife, mange, stress, pulmonary congestion, etc.

Huntzinger et al. (2005) estimated annual survival of radio-collared wolves in the Upper Peninsula of Michigan from 1999 to 2005. Two sets of annual survival rates were calculated. One set of annual estimates assumed that the survival rate of radio-collared wolves that went missing was the same as collared wolves that were monitored. The second set of annual estimates assumes a worse-case scenario in which radio-collared wolves that went missing all died. The best estimate of survival is expected to be found somewhere between the two sets. Estimates of annual survival rate varied between 0.65 and 0.85 (average of 0.76) when survival of missing wolves is the same as monitored wolves and between 0.54 and 0.82 (average of 0.68) when missing wolves are assumed to have died. The average difference between the two estimates is approximately 8%, which could be important biologically (Huntzinger et al. 2005). Although the confidence limits are large and the estimates vary annually, there is no trend in annual survival. In other words, survival of wolves did not increase or decrease during this period. Huntzinger et al. (2005) also evaluated seasonal patterns of survival and found, on average, summer survival (≈0.94) was higher than winter survival (≈0.79).

O'Neil (2017) provided more current analyses of survival and cause-specific mortality of wolves in the Upper Peninsula of Michigan. Annual wolf mortality was about 25% during 1994-2013, with human-caused mortality the dominant source in Michigan wolves, representing 17% annually (O'Neil 2017). Across years (i.e., 1994-2013), wolf survival decreased overall with greater evidence corresponding with increased potential for conflicts with humans as opposed to natural (e.g., intraspecific aggression) causes of mortality (O'Neil 2017). O'Neil (2017) noted this density dependent survival was also landscape dependent, with mortality risk increasing in areas with greater proportions of agriculture. Like Huntzinger et al. (2005), O'Neil (2017) identified greater wolf survival during summer than in winter.

Immigration and Emigration

Dispersal is highly variable among wolves, with attributes of dispersal including success dependent on environmental, social, and individual factors (Morales-González et al 2022). Most wolves disperse because animals rarely assume a breeding position within their natal pack (Mech and Boitani 2003a).

In the western United States, males were more likely than females to disperse (Jiminez et al. 2017); however, earlier studies found no differences in rates of dispersal between males and females (Boyd and Pletscher 1999, Mech and Boitani 2003a, Kojola et al. 2006). However, females are more likely to be successful, due in part to shorter dispersal distances (Morales-González et al. 2022). Dispersal rates may be greatest at lower and higher wolf densities, and wolves tend to avoid areas of greater human activity (Morales-González et al. 2022). Frequency of dispersal appears to increase with pack density and overall density of wolves (Gese and Mech 1991, Jiminez et al. 2017). Success of dispersals was reduced due to human-caused mortality, as well as distance of dispersal events (Morales-González et al. 2022). A global synthesis of wolf dispersal, including 21 studies found an average of about 77% of dispersing wolves became established in a new territory (Morales-González et al. 2022).

Wolves are capable of dispersing long distances; a few movements greater than 500 mi (800 km) have been reported (Fritts 1983, Ballard et al. 1983, Boyd et al. 1995). A male wolf captured and tagged in Gogebic County, Michigan in 1999 was later killed near Trenton, Missouri in October 2001. The straight-line distance between the two points is 457 mi (756 km). Another male wolf was incidentally captured by a coyote trapper in Mackinac County, Michigan in 2020.The wolf dispersed shortly after capture and was killed less than seven months later but not before travelling a minimum of almost 2,000 miles (3,219 km) to Manitoba, Canada. In a recent synthesis of wolf dispersal patterns, the greatest reported straight-line distance was 1,092 km (Morales-González et al. 2022). Though methodologies varied markedly across studies, the range of reported minimum dispersal distances for wolves was 41 to 3,950 km (Morales-González et al. 2022). Specific to the western Great Lakes region of the United States, movements of wolves among Minnesota, Wisconsin, and Michigan have been confirmed through the recovery or observation of marked animals (ear-tagged and/or radio-collared) (Mech et al. 1995; Wisconsin DNR, unpublished data; Michigan DNR, unpublished data). There is also evidence of wolf movements between the eastern Upper Peninsula and Ontario across Whitefish Bay and the St. Mary's River (Jensen et al. 1986, Thiel and Hammill 1988, Michigan DNR unpublished data). Movements and gene flow among these jurisdictions helps preserve or enhance genetic diversity within populations and helps mitigate the effects of detrimental demographic fluctuations due to environmental catastrophes (Simberloff and Cox 1987, Boitani 2000).

Wolf Food Habitats

Wolves prey on a variety of wildlife species, and predation on those species often changes seasonally and geographically (Van Ballenberghe et al. 1975, Voigt et al. 1976, Fritts and Mech 1981, Potvin et al. 1988, Fuller 1989, Mech and Peterson 2003, Newsome et al. 2016). In general, prey abundance, distribution, vulnerability and behavior influence a prey species' importance to wolves as a food source. In multiple-prey systems, the more-vulnerable species commonly predominates as the main food source for wolves (Van Ballenberghe et al. 1975, Fritts and Mech 1981).

Worldwide, gray wolf diet includes primarily medium- and large-sized ungulates and overall dietary diversity is regionally similar (Newsome et al. 2016). In Minnesota, white-tailed deer (*Odocoileus virginianus*), moose and beaver (*Castor canadensis*) comprise the majority (>75%) of annual wolf diet. The predominance of deer remains in wolf scat indicates deer are the principal prey throughout the year despite relatively high densities of moose (Van Ballenberghe et al. 1975). Seasonal variation, or prey switching, can occur in wolf populations and is usually associated with changes in prey abundance or vulnerability (Newsome et al. 2016). For example, during spring and early summer months, beaver become an important food source (Van Ballenberghe et al. 1975, Voigt et al. 1976, Fritts and Mech 1981, Potvin et al. 1988, Fuller 1989, Gable et al. 2018b). In June and July, wolves are thought to prey heavily on deer fawns and moose calves when they are more vulnerable and occur in relatively high densities (Voigt et al. 1976, Fritts and Mech 1981, Fuller 1989). Mandernack (1983) analyzed scats of Wisconsin wolves to determine the relative abundance of prey species in their diet. Deer comprised 55% of the diet, beaver comprised 16%, snowshoe hare (*Lepus americanus*) comprised 10%, and other small mammals and miscellaneous items comprised 20%. Beaver provided as much as 30% of a Wisconsin wolf's spring diet.

In the Upper Peninsula, white-tailed deer and moose constitute the ungulate prey available for wolves. However, moose are rarely preyed upon by wolves, probably due to the lack of overlap in distribution with wolf pack territories (particularly early in recolonization), the low abundance of moose in comparison to deer, and differences in vulnerability (Michigan DNR, personal communication). Research in Michigan indicates deer are the primary prey item for wolves (e.g., Vucetich et al. 2012; Kautz et al. 2019, 2020; Petroelje et al. 2021), with small mammals such as beaver, snowshoe hare and ruffed grouse (*Bonasa umbellus*) making up lesser percentages of their diet (Huntzinger et al. 2004, Petroelje et al. 2021).

For white-tailed deer in the Upper Peninsula of Michigan, wolves were an important predator of adults, but not fawns. Of 363 radio-collared deer fawns monitored to 16 weeks of age, 12 died of known wolf predations, representing 8% of known-cause mortalities and 3.5% of the total fawn sample (Kautz et al. 2019, MDNR, unpublished data). In this same study, coyotes were the single greatest predator of fawns (13.1% of the total fawn sample), followed by black bears (*Ursus americanus*; 7.8%), and bobcats (*Lynx rufus*; 5.4%); unidentified predation was 8.8% of the total fawns sampled (Kautz et al. 2019, MDNR, unpublished data). In contrast, wolves killed 56 of 424 radio-collared adult female deer, representing 42% of known cause mortality and 8.6% of the total population (Kautz et al. 2020, MDNR, unpublished data). However, most adult female predations occurred in late winter and early spring with a third or more deer in poor nutritional condition, suggesting wolf predation was partly compensatory (Kautz et al. 2019, MDNR, unpublished data).

Though ungulates are the dominant prey of wolves worldwide (Newsome et al. 2016) and the Great Lakes region (DelGiudice et al. 2009), early studies in the Upper Peninsula found wolves ate shrews, snowshoe hares, red squirrels (*Tamiasciurus hudsonicus*), mice, ruffed grouse, crayfish and grass in addition to white-tailed deer (Stebler 1944, 1951). More recently, prey identified at 164 wolf "cluster" sites (i.e., a group of locations from a GPS-collared wolf suggesting extended time spent in an area) during summer, was comprised primarily of white-tailed deer (76.8%; 12.2% adult, 64.6% fawn), followed by beaver (3%), muskrat (*Ondatra zibethicus*; 2.4%), raccoon (*Procyon lotor*; 2.4%), snowshoe hare (1.8%), coyote (*Canis latrans*; 1.2%), ruffed grouse (*Bonasa umbellus*; 1.2%), Canada goose (*Branta canadensis*; 0.6%), wild turkey (*Meleagris gallopavo*; 0%), and unknown species (4.3%) (MDNR, unpublished data).

However, domestic livestock can potentially alter wolf diets. In a more recent Michigan study, diet analyzed from 152 scat samples collected during summer in an area of the south-central Upper Peninsula with livestock carcass dumps found 70% white-tailed deer (62% adult, 8% fawn), 22% cattle, and 6% cottontail rabbit (*Sylvilagus floridanus*) or snowshoe hare (*Lepus americanus*) (Petroelje et al. 2019). In contrast, 328 summer wolf scats from an area in the western Upper Peninsula without livestock carcass dumps contained 78% white-tailed deer, (40% adult, 38% fawn), 0% cattle, 3% cottontail rabbit or snowshoe hare, and 19% rodents (Petroelje et al. 2019).

Wolf–prey Interactions

The influence of wolves on prey populations has been the topic of much research and debate. Results of public surveys, anecdotal conversations with stakeholders, and other forms of public participation indicate many Michigan residents perceive risks from wolves that include a reduction in deer distribution or abundance, safety of livestock or humans, and effects on the general way of life in some areas of Michigan, especially the Upper Peninsula. Nevertheless, many Michigan residents also greatly value the presence of wolves for the role they play in ecosystem functioning, recreational or aesthetic benefits, and existence values now and in the future. Research suggests the perceived level of impacts created by wolves depends on local conditions and the nature of individual experiences with wolves. In some situations, wolves may significantly reduce local prey populations, whereas in others, the impact may be negligible (Mech and Peterson 2003). The wolf–prey relationship is complex and is influenced by many factors, including the number of prey species in a system, the relative densities of wolves and prey, the responses of both wolves and prey to fluctuations in prey densities, and the effects of environmental influences (e.g., winter severity and disease) on wolves and prey (Vucetich et al. 2002; Mech and Peterson 2003; Sand et al. 2012; Kautz et al. 2019, 2020). Disease (e.g., chronic wasting disease) can also potentially increase prey vulnerability to wolf predation (e.g., Brandell et al. 2022) but this has not been rigorously tested in a wolf-prey system. Each of these factors varies geographically and temporally; thus, there is no general answer to the question of how wolves affect prey densities. A more detailed discussion of wolf–prey interactions is presented in Chapter 6: Wolf–prey Relationships.

Ecological Function

Wolves are a top predator and at times can have a major influence on the ecological system in which they live (Mech and Boitani 2003b; Wilmers et al. 2006). Primary effects of wolves include the removal of less-fit individual prey, control of prey numbers, and increased availability of food for scavengers (Mech 1970; Stahler et al. 2006, Vucetich et al. 2004, Kautz et al. 2020). Wolves may also limit populations of competitors such as coyotes (Crabtree and Sheldon 1999). For example, Fowler et al. (2021) found some support for wolves limiting coyote occurrence in the Upper Peninsula. Densities of wolves and coyotes in the Upper Peninsula were inversely related, with coyote diet, space use, and daily activity less variable in areas of lower wolf densities as apparent means to allow their coexistence (Fowler et al. 2022). These primary effects can also cause changes (indirect effects) in other elements of the ecosystem. These indirect effects have been termed 'trophic cascades' (Paine 1966) because changes at one trophic level (e.g., carnivores such as wolves) cause changes at another trophic level (e.g., herbivores such as elk [Cervus elaphus]). However, these relationships are complex and not well understood (see Eisenberg et al. 2013). Finally, wolves and other carnivores can provide ecosystem services of direct and indirect benefit to humans (see Lozano et al. 2019).

On Isle Royale, McLaren and Peterson (1994) documented a top-down trophic cascade among wolves, moose, and balsam fir (*Abies balsamea*). In this system, wolves controlled moose numbers and moose controlled growth of balsam fir. However, this effect was reduced markedly following occurrence of canine parvovirus (Wilmers et al. 2006). A similar relationship has been observed in Yellowstone National Park after wolves were reintroduced. Wolf predation on elk is allowing several tree species, which were formerly limited by elk browsing, to recover (Ripple and Larsen 2000, Ripple et al. 2001, Ripple and Beschta 2003). The mechanism that starts the trophic cascade may be direct (wolves limit prey numbers; McLaren and Peterson 1994), or indirect (risk of wolf predation causes a change in ungulate browsing patterns; Ripple and Beschta 2004, Beschta et al. 2018). However, more recent work suggests a more limited effect of wolves facilitating this behaviorally-mediated trophic cascade, where effects of elk browsing on aspen were not reduced in areas where elk were at greater risk of wolf predation (Kauffman et al. 2010, Fleming 2019).

Wolf Habitat

Wolves are habitat generalists and have the potential to occupy habitat-diverse areas with an adequate abundance of hoofed prey (Fuller 1995, Singh and Kamara 2006, Wolf and Ripple 2016, O'Neil 2017, USFWS 2020, Marquard-Petersen, 2021). Given sufficient prey, the chance of an area being occupied and the number of wolves that could occupy the area is related in part to the proximity of source populations and the extent of human-caused mortality (Fuller 1995, Creel and Rotella 2010, Wolf and Ripple 2017).

Road density has been used as an index of wolf–human contact and appears to be related to illegal and accidental killing of wolves (Mladenoff et al. 1995, Mladenoff et al. 1999, Person and Russell 2010, Dennehy et al. 2021). A spatial habitat model based on road density has been used to predict areas of wolf re-colonization in the northern portions of Minnesota, Wisconsin and Michigan (Mladenoff et al. 1995). This model predicted a road-density threshold of 0.72 mi/mi^2 (0.45 km/km^2) where wolves were considered unlikely to occupy areas with road densities greater than this threshold. Although at this period of recolonization the model successfully predicted wolf occupancy in northern Wisconsin (Mladenoff et al. 1999), the results for the Upper Peninsula of Michigan were questionable because areas of low prey (deer) density (Doepker et al. 1995) were identified as suitable habitat. Areas with low deer density are less likely to be occupied by wolves (e.g., O'Neil 2017). Recognizing this problem, Potvin et al. (2005) developed a spatial habitat model for the Upper Peninsula which incorporated measures of road density and deer density. This model identified a road-density threshold of 1.1 mi/mi^2 (0.7 km/km^2) and a deer-density threshold of 6–15 deer/mi^2 (2.3–5.8 deer/km^2). The deer-density threshold is near the point where wolves become nutritionally stressed (Messier 1987) and wolf pack occurrence in the Upper Peninsula is strongly associated with areas of overwintering white-tailed deer (O'Neil 2017). The two models produced similar estimates of habitable area (Mladenoff et al. 1999: 11,331 mi^2 or 29,348 km^2; Potvin et al. (2005): 10,695 mi^2 or 27,700 km^2) but differed in how the suitable habitat was distributed. The Potvin et al. model predicted most occupiable habitat is in the southern portions of the Upper Peninsula. By contrast, the Mladenoff et al. model suggests many areas in the northern portion of the Upper Peninsula will be occupied. More recent estimates (2007-2013) predicted greater densities in the southern and eastern portions of the Upper Peninsula (O'Neil 2017), supporting the Potvin et al. (2005) model.

Using an earlier version of the Potvin et al. (2005) model, Potvin (2003) estimated the Northern Lower Peninsula of Michigan contained approximately 3,089 mi^2 (8,000 km^2) of suitable wolf habitat. Gehring and Potter (2005) applied the Mladenoff et al. (1995) model to the Northern Lower Peninsula and estimated 1,634 mi^2 (4,231 km^2) of suitable habitat was available. A more recent modelling effort using snow-tracking data (2017-2020) from Michigan, Wisconsin, and Minnesota estimated about 6,992 mi^2 (18,110 km^2) of the Lower Peninsula was suitable for wolves (van den Bosch et al. 2022). These modeling efforts suggest wolf habitat in the Northern Lower Peninsula is more fragmented than habitat in the Upper Peninsula. Variation in estimated suitable habitat across these studies is due in part to differences in methods used. However, we note that species distribution models assume species are in equilibrium with their environment, yet recolonizing species are not (Guisan and Thuiller, 2005).

Previous estimates of suitable wolf habitat may be conservative because wolves exhibit behavioral plasticity and can select for areas previously considered unsuitable (Mladenoff et al., 2009).

Biological Carrying Capacity

Biological carrying capacity is generally defined as the number of animals the available habitat can support. Estimates of biological carrying capacity are of interest but are usually imprecise. Wolf numbers appear to be related to food supply (Mech and Peterson 2003) rather than social or territorial restrictions (Packard and Mech 1980). There is a general relationship between wolf density and prey density (Fuller 1989, Fuller et al. 2003), but prey density is not equivalent to food supply because some prey are not vulnerable. Potvin (2003) used an estimate of the relationship between wolf density and deer density (Fuller 1989) to estimate the number of wolves the Upper and Northern Lower Peninsulas of Michigan could support. The estimates of deer density in Michigan were based on counts of deer pellet groups. Population estimates derived by the pellet-group count technique are sensitive to the estimate of the average number of deer pellet groups an individual deer deposits per day. Estimates of this deposition rate range from 13 to 31 pellet groups per day (Ryel 1971, Rogers et al. 1987). Potvin (2003) used the ends of the range of pellet-group deposition to bound his estimates of carrying capacity. He estimated the carrying capacity of the Upper Peninsula ranged from 590 to 1,330 wolves. The carrying capacity of the Northern Lower Peninsula ranged from 210 to 480 wolves. Obviously, the estimates of carrying capacity vary considerably because of the uncertainty in the estimate of pellet-group deposition rate. Importantly, the uncertainty associated with the model that describes the relationship between wolf and deer density is not reflected in Potvin's carrying capacity estimates. The uncertainty associated with estimates of carrying capacity limits their value for making management decisions. Nevertheless, point estimates for the minimum number of wolves during late winter in the Upper Peninsula have exceeded 600 individuals since 2011. Considering comparative wolf survey work in Wisconsin (Stauffer et al. 2021), the actual number of wolves is somewhat higher, and well within the estimated carrying capacity range reported by Potvin et al. (2005). In addition, estimates of the minimum number of wolves in the Upper Peninsula have been similar since 2011. Therefore, under current conditions (e.g., habitat, prey) wolf abundance in the Upper Peninsula may be at or near carrying capacity.

Population Viability

The goal of Michigan's current wolf management plan is to ensure the long-term survival of a self-sustaining wolf population. The plan adopted the definition of a viable isolated population identified in the Eastern Timber Wolf Recovery Plan (U.S. Fish and Wildlife Service 1992) as a recovery criterion. When the wolf population maintained a level of 200 or more wolves for 5 consecutive years, the species could be removed from the State's List of Threatened and Endangered Species. The wolf population in Michigan met this criterion in 2004 however State delisting did not occur until March 12th, 2007. This population criterion was a conservative approach because the wolf population in the Upper Peninsula is not isolated. Movements of radio-collared wolves among Minnesota, Wisconsin, and Michigan have been documented (Michigan DNR, unpublished data). Early population viability analyses have been conducted for wolves in Wisconsin and Michigan (Rolley et al.1999, Hearne et al. 2003). These analyses can aid understanding of population dynamics (White 2000) and help identify information gaps. Further, Maletzke et al. (2015) developed a spatially-explicit population viability model for the State of Washington with potential for application for wolves in other areas. However, resulting estimates of minimum population sizes necessary to avoid extinction should be viewed with great caution because of uncertainty of inputs such as frequency of catastrophic events and effects of environmental fluctuations (Fritts and Carbyn 1995), limited integration of genetic and evolutionary process (Pierson et al. 2015), and limitations to fully addressing species conservation and management (Wolf et al. 2015).

History of Wolves in Michigan

The wolf has been part of Great Lakes fauna since the melting of the last glacier and as such is native to the land area known as Michigan. Stebler (1951) suggested that pioneer documents and museum specimens of gray wolves show wolves were once present in all counties of Michigan.

Wolves have an important role in the tribal culture and beliefs of the Anishinabek of the Great Lakes. In the Anishinabek creation story, Ma'iingan (wolf) is sent to walk as an equal with Original man who is lonely. Ma'iingan and man traveled together to name and visit all the plants, animals and places on earth. Later, the Creator instructed them to walk their separate paths, but indicated each of their fates would be always tied to that of the other (Ziibiwing Center 2004). David (2009) provides additional background on the cultural importance of wolves to the Ojibwe in the western Great Lakes region.

Settlers brought their wolf prejudices with them (Lopez 1978). European werewolf mythology, fairy tales, and religious beliefs, along with views that wolves were incompatible with civilization, resulted in the persecution of wolves in Michigan as well as the rest of the United States. These Old-World myths led to the near-extermination of wolves in the United States. Hampton (1997) called the effort to eradicate wolves "the longest, most relentless and most ruthless persecution one species has waged against another."

Assisting the exploitation, the United States Congress passed a wolf bounty in 1817 in the Northwest Territories, which included what is now Michigan. A wolf bounty was the ninth law passed by the first Michigan Legislature in 1838. A wolf bounty continued until the period between 1922 and 1935, when a State trapper system was in effect. The bounty was reinstated in 1935 and repealed in 1960, only after wolves were nearly eliminated from the State. Michigan wolves were given legal protection in 1965.

By the time bounties were imposed in the 1800s, wolves were nearly extirpated from the southern Lower Peninsula. They were absent from the entire Lower Peninsula by 1935, if not sooner (Stebler 1944). In the more sparsely settled Upper Peninsula, the decline was less precipitous. In 1956, the population was estimated at 100 individuals in seven major areas in the Upper Peninsula (Arnold and Schofield 1956). The Michigan wolf population was estimated at only six animals in the Upper Peninsula in 1973. Sporadic breeding and occasional immigration of wolves from more secure populations in Ontario and Minnesota were postulated as the factors that maintained the small number of wolves in the Upper Peninsula (Hendrickson et al. 1975). It is likely that a few animals persisted in remote areas of the Upper Peninsula and that wolves were never extirpated from the State.

Beginning around 1973, the wolf population in Minnesota began to expand southward from its northern range. In 1975, a pack of wolves occupied a territory in both Pine County, Minnesota, and Douglas County, Wisconsin (Thiel 1993). This signified the beginning of re-occupation of former wolf range in Wisconsin. Since 1975, the wolf population in Wisconsin has grown to more than 1,100 animals occupying suitable habitat in northern and central portions of the state (Wisconsin Department of

Natural Resources 2021). Wolves occupying the Upper Peninsula have probably largely descended from immigrants from Wisconsin (Thiel 1988) and Minnesota (Mech et al. 1995).

Only one wolf reintroduction has been attempted in mainland Michigan. Four wolves from Minnesota were released in Marquette County in March 1974 and all died as a result of direct human activities between July and November 1974. These wolves did not reproduce and did not contribute to the current wolf population (Weise et al. 1975). A more detailed synthesis of the history of wolves in Michigan was provided by Beyer et al. (2009).

Current Status and Distribution in Michigan

A winter wolf survey has been used to monitor the status of Michigan wolves and has been important for documenting the recovery of the population. The purpose of the winter wolf survey is to determine a minimum estimate of the number of wolves in the Upper Peninsula, excluding Isle Royale. Prior to 2007, the Michigan DNR and USDA Wildlife Services estimated wolf abundance in the Upper Peninsula (UP) by surveying suitable wolf habitat throughout the entire peninsula during the winter months, when snow cover made wolves and their tracks easier to observe. Surveys during the winter months provided an estimate of the wolf population at its smallest size in the annual wolf population cycle. The winter survey consists of intensive and extensive searches of roads and trails by truck and snowmobile for wolf tracks and other sign (Potvin et al. 2005). The integrity of the minimum population estimate is maintained by using established procedures designed to avoid double-counting of wolves (Huntzinger et al. 2005).

As the wolf population increased, separating adjacent packs became more difficult and time consuming. In 1995, the wolf population was estimated at a minimum of 80 animals distributed among 27 packs and the average distance from a pack to its nearest neighbor was 28 km (17.5 mi). By 2006, the wolf population had grown to at least 434 animals and 91 packs and the average distance from a pack to its nearest neighbor had declined more than 50% (13 km; 7.9 mi).

Because a complete survey of the UP was becoming less practicable, a new approach to estimating wolf abundance was developed in 2007. The new sampling scheme is a geographically stratified sampling technique which produces an unbiased, precise estimates of wolf abundance (Potvin et al. 2005). The sampling scheme developed reduces the area that needs to be searched, allowing trackers to spend more time in smaller areas and allows trackers to search areas more thoroughly to determine whether wolves observed in adjacent areas belong to the same packs or different packs.

The wolf population has shown steady growth since the natural recovery began in the early 1990s (Figure 1-1). Except for 1997, the wolf population had been increasing each year to 2011. Since 2011 the wolf population has remained stable ranging from 618 to 695 with overlapping 95% confidence limits, suggesting wolves may have reached their carrying capacity in the Upper Peninsula.

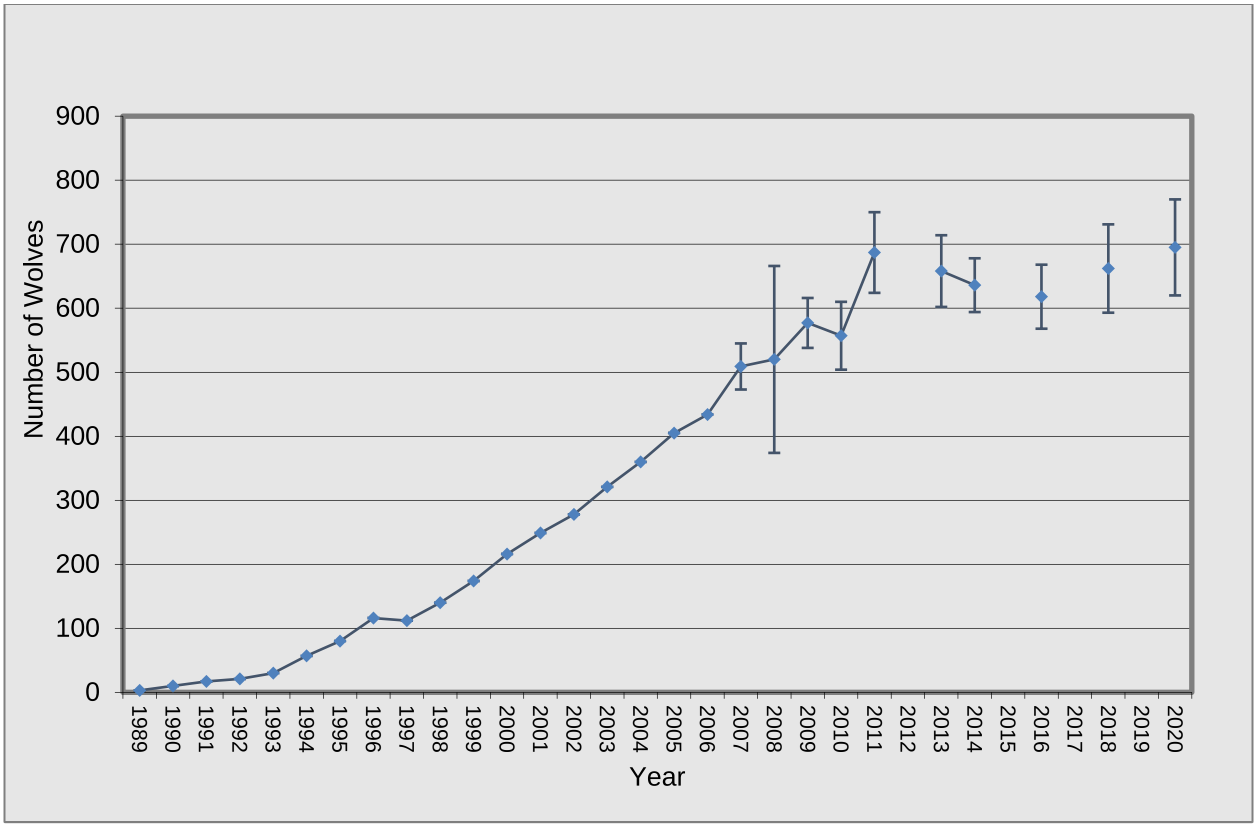

Figure 1-1. Minimum estimates of the number of wolves in Michigan's Upper Peninsula, 1989–2020.

Wolves can be found in every county of the Upper Peninsula; however, wolf density is variable. In 2005 wolf density was higher in the western Upper Peninsula (about 12 wolves/1000km^2 in 2005) than in the eastern Upper Peninsula (about 7 wolves/1000km^2 in 2005) (Huntzinger et al. 2005). However, during the 2020 survey this density difference between the eastern and western Upper Peninsula was no longer detected (about 16 wolves/1000 km^2).

The wolf survey in the NLP is significantly different because wolves, if present, are at such low-densities it makes the Upper Peninsula track survey protocol impractical. Instead, a targeted search approach based on citizen reports of wolves or wolf sign is used to concentrate efforts in areas more likely to have wolves. In October 2004, a wolf that had been captured and radio-collared in the eastern Upper Peninsula was captured and killed by a coyote trapper in Presque Isle County of the Lower Peninsula. This event represented the first verification of a wolf in the Lower Peninsula in at least 65 years.

In 2010, three young of-the-year canids were captured in Cheboygan County of the NLP and were initially identified as wolf pups based on dentition, size (especially length of legs and size of the feet and toes) and weight (Wheeldon et al. 2012). Genetic analyses indicated; however, the pups were coyotes rather than wolves. In addition, the analyses found evidence of maternal introgression from a Great Lakes wolf (hybrid heritage from gray wolves and eastern wolves) in their pedigree. The disagreement between the physical appearance of these animals and the genetic assignment indicates the Department should use genetic testing to validate classifications based on appearance or tracks until wolves have re-established themselves in the LP in significant numbers (Wheeldon et al. 2012).

In 2014, while using deer carcasses and trail cameras for an eagle survey, biologists from the Little Traverse Bay Bands of Odawa Indians captured what appeared to be a wolf on a trail camera and were able to collect a scat sample. DNA analysis of the scat found that the wolf was a male and the mitochondrial DNA haplotype was an Old World (gray wolf) haplotype and is only rarely observed in eastern wolves.

During the targeted winter track surveys in the NLP, wolf trackers have occasionally documented tracks consistent with wolves. Although it is possible that wolves currently occur in the NLP, as of April 2021, no genetic verification exists.

Population estimates of wolves in Michigan are often criticized by members of the public as grossly underestimating the actual population size. During a 5-year period (2001–2005), two independent wolf surveys were conducted in a 750-mi^2 (1940-km^2) area to evaluate the Michigan Department of Natural Resources (DNR) population estimates (B. Huntzinger, Michigan Technological University, unpublished data). The surveys were conducted by Michigan DNR and Michigan Technological University (MTU). No communication on survey results between the two groups was allowed until each year's survey was completed. The MTU crew spent the majority of the winter counting and recounting wolves in the study area, whereas the DNR crew spent much less time in the area. Thus, it was assumed that the MTU estimates would be more accurate. Overall, the counts were similar, suggesting the Michigan DNR survey results are reliable (Table 1-3).

Table 1-3. Two independent wolf-population counts conducted by the Michigan Department of Natural Resources (DNR) and Michigan Technological University (MTU) for five winter surveys conducted in an area approximately 750 mi2 (1940 km2) in the Upper Peninsula of Michigan (B. Huntzinger, MTU, unpublished data).

Pack	DNR 2001	MTU 2001	DNR 2002	MTU 2002	DNR 2003	MTU 2003	DNR 2004	MTU 2004	DNR 2005	MTU 2005
Ewen	6	5	3	3	3	3	4	4	4	6
Baraga Pl.	5	5	7	8	7	7	7	7	8	8
Clear Cr.[a]	N/A	N/A	0	0	0	3	0	2	0	4
Silver Mt.[a]	N/A	N/A	0	0	0	2	0	0	0	2
Sidnaw	N/A	N/A	4	4	3	3	8	4	11	6
Trout Cr.	N/A	N/A	5	5	2	2	4	6	4	5
Gardner	N/A	N/A	N/A	N/A	6	5	9	8	7	3
Curwood	N/A	N/A	N/A	N/A	9	11	3	4	5	2
Loners	0	1	0	0	0	2	0	3	0	1
Totals	11	11	19	20	30	38	35	38	39	37

[a]These packs may be included in the Baraga Plains pack by the DNR.

Isle Royale

Isle Royale is a 210-mi^2 (544-km^2) island in northwestern Lake Superior. The nearest mainland is Ontario, 15 miles northwest of the island. Isle Royale National Park was authorized by Congress on 03 March 1931 by President Herbert Hoover "to conserve a prime example of North Woods Wilderness," but was not established until 3 April 1940 by President Franklin D. Roosevelt, then dedicated in 1946 (Beyer et al. 2006).

Protection of the native flora and fauna became the primary management goal. The first evidence of moose was thought to have been found in 1904 (Peterson 1995a). Prior to the arrival of moose on Isle Royale, the primary large mammals were the woodland caribou (*Rangifer tarandus*), lynx (*Lynx canadensis*) and coyotes. Wolves were first thought to have arrived in 1948 when a few tracks were reported (Mech 1966, Peterson 1995a). A failed attempt to release four captive wolves from the Detroit Zoo occurred in 1952 (Peterson 1995a). When wolves arrived naturally on the island, they found a substantial moose population, which became their primary food source.

The wolf and moose populations on the island followed a pattern of dynamic fluctuations, wherein high moose numbers (particularly older moose) were followed by higher wolf numbers. Wolves influenced moose numbers predominantly through the direct killing of calves and have remained the only consistent source of moose mortality on the island. The moose–wolf population patterns held until a dramatic crash occurred in the wolf population in the early 1980s, in which wolf numbers dropped from 50 to 14. There is circumstantial evidence the decline in wolf numbers was related to the introduction of canine parvovirus (Peterson 1995a, Kreeger 2003). Wolf reproduction progressively declined during 1985–1992; numbers dropped to their lowest level (a dozen animals). The moose population grew steadily throughout the 1980s and 1990s, but the wolf population increased more slowly. The wolf population increased to 30 animals in 2005, one more than the previous year (Peterson and Vucetich 2005). The moose population remained comparatively low during the 2000s before increasing overall during the 2010s, corresponding with an overall decline in wolf abundance during the 2010s (Romanski et al. 2020). Beaver abundance as indexed by active beaver colonies also increased on the island during the 2010s (Romanski et al. 2020).

Following 2006, wolf abundance on Isle Royale declined and extirpation seemed likely (Vucetich and Peterson 2015), in 2015 the NPS began to formally determine how to manage wolves and assessed 4 management alternatives documented in an environmental analysis (NPS 2018a). The selected alternative included one or more introductions of wolves to Isle Royale within 5 years (NPS 2018b). The intent of this alternative was to introduce enough wolves to function as an apex predator and to facilitate pair formation and pack establishment (NPS 2018b). Implementation of this alternative required the NPS to translocate about 20–30 wolves from locations throughout the Great Lakes region with suitable genetic diversity. The proposed number of wolves to introduce reflected the long-term average annual number of wolves on Isle Royale (*n* = 22; Vucetich and Peterson 2016).

Nineteen wolves captured in Michigan, Minnesota, and Ontario during September 2018–2019 were translocated to Isle Royale (Romanski et al. 2020). These authors estimated 14 wolves present on Isle Royale on 14 April 2020. Though 8 wolves died following introduction, successful reproduction has occurred (Romanski et al. 2020). Increased wolf abundance on Isle Royale has corresponded with a purported decline in moose abundance. In addition to predation of adult moose, spring-early fall diets of introduced wolves during 2019-2020 included beaver, calf moose, and other species including red fox (Romanski et al. 2020, Petroelje et al. 2022).

Chapter 2 Public Perceptions of Wolves and Wolf Management

Executive Summary

The 2021 public survey conducted by Michigan State University (Riley et al. 2022) assessed perceptions of wolves and wolf management by Michigan residents in the three regions: the Upper Peninsula (UP), the Northern Lower Peninsula (NLP), and the Southern Lower Peninsula (SLP). Randomly-drawn samples of households in each region provided representation for analysis. A random selection of licensed deer hunters and trappers were sent a similar questionnaire with additional questions related to animal abundance and stakeholder activities related to wolves. In addition, households in the UP and NLP which were believed to be involved with livestock-related agricultural activities, derived from mailing lists of livestock producer groups and Michigan State University Extension, were also sent questionnaires that were the same as the general population sample.

Introduction

Management of wolf population size and distribution involves two major categories of issues: (1) establishing goals and (2) selecting methods to achieve those goals. This chapter discusses the social issues associated with establishing goals for wolf abundance and distribution in Michigan. The next chapter (Managing Wolf Population Size and Distribution) discusses the biological impacts and social acceptability of the management options for achieving established goals.

Background

Goals for wolf management are often determined within a social context where stakeholder values and priorities must be addressed. Wolf management is contentious, as different publics, holding distinct wildlife value orientations, often disagree on acceptable management activities (Dietsch et al. 2018; Lute, Bump, and Gore 2014). When wolf hunting and trapping is considered as a possible management activity, these disagreements are amplified (Lute et al. 2014). Understanding public attitudes towards wolves can help identify where disagreement or conflict lies, allowing the DNR to make informed decisions that are responsive to conflict and consider public values. Past research on the human dimensions of wolf management relates to:

- knowledge of and attitudes towards wolves, predators, and wolf management activities (Bruskotter, Schmidt, and Teel 2007; Bruskotter, Vaske, and Schmidt 2009; Hook & Robinson, 1982; Kellert, 1990; Landon et al. 2020; Jens, Maria, and Anders 2015; Skogen & Thrane 2008);
- behaviors towards wolves (Kellert, 1990);
- social carrying capacity for wolves and wolf tolerance (Beyer et al. 2006; Peyton 2007; Slagle, Wilson, and Bruskotter 2022);
- preferences for wolf management processes (Lute & Axelrod 2015);
- public engagement and wolf management (Lute & Gore 2014a);
- the role of social identity (Lute et al. 2014; Lute & Gore 2014b; Schroeder et al. 2021), emotion (Vaske et al. 2021), value orientations (Herman, Voß, and Menzel 2013; Manfredo et al. 2020), and political affiliation (Ditmer et al. 2021; vanEeden et al. 2021) relative to perceptions of wolves and wolf management;

- the role of media reporting (Killion et al. 2019; Niemec et al. 2020);
- integrating social science in wolf management decision making (Niemec et al. 2021);
- and effectiveness of various wolf management practices (Lute et al. 2012).

As wolf populations increase and Michigan citizens and stakeholders have more frequent direct experiences with wolves, their attitudes may become stronger, affecting decision-making (Heberlein & Ericsson 2005). A meta-analysis that included 105 quantitative surveys conducted in 24 European countries from 1976 to 2012 suggests that attitudes toward wolves differ from those of other large carnivores and that the longer that people live with wolves, the less positive are attitudes toward wolves (Dressel et al. 2015). Furthermore, an increase in the wolf population may lead to greater conflicts related to wolves and wolf management.

The last time the MDNR sponsored a public attitudes survey to measure preferences and tolerances of Michigan residents regarding wolves was in 2005 (Beyer et al. 2006). Since that last survey of public attitudes was conducted, the federal status of wolves in Michigan has seen several changes. Wolves were removed from federal protection by the U.S. Fish and Wildlife Service in the Great Lakes in the spring of 2007, only to be relisted in the fall of 2008. By the spring of 2009, wolves were again delisted in the Western Great Lakes distinct population segment; however, within the same year litigation returned wolves to federal protection. Delisting was attempted again in 2012, only to have wolves returned to federal protection in 2014. In November 2020, the Final Rule was published, under the title "Endangered and Threatened Wildlife and Plants" to remove gray wolves from the Federal List of Endangered and Threatened Wildlife, this became effective in January 2021. However, in Feburary 2022 a U.S. District Judge in the Northern District of California vacated the U.S. Fish and Wildlife Service order from November 2020, returning wolves in the Great Lakes back to federal protection. The changing federal status of wolves, along with changing human demographics in the state and the more than fifteen years since the last public survey of wolf-related attitudes was conducted, suggest a changing context for wolf management in Michigan. A reassessment of public attitudes towards wolves was critical to ensure DNR has the most contemporary scientific data on which to base management within this changing context.

The hunting and trapping of wolves after they become delisted is one of the most divisive and contentious issues in wolf management. It is often viewed critically by wolf advocacy organizations, especially when it is managed by a state wildlife agency in which they have little trust and confidence (Nie 2003). Recreational harvest was the only issue that received no consensus during the 2006 Michigan Wolf Roundtable, a diverse stakeholder committee tasked with recommending guiding principles for MDNR to follow for wolf management under delisting.

Evidence regarding public acceptance of a recreational harvest of wolves in Michigan is inconsistent. In 2005, a Michigan State University public attitudes survey found 67% of Michigan residents supported the use of a limited number of permits to licensed hunters to shoot wolves during a controlled hunting season (Beyer et al. 2006). A Marketing Resource Group working with Mitchell Research found similar results when they asked the same question on two different surveys', one conducted prior to the 2014 voter referendums and other was conducted shortly after the vote. In contrast, the 2014 voter referendums which vetoed Public Act 520 of 2012 and Public Act 21 of 2013 that would have designated wolves as a game animal as a measurement for the public acceptance for the harvest of wolves suggest a lack of public support for recreational harvest. However, three months before election day, citizen-initiated legislation rendered the vote on the referendums moot, further complicating interpretation of the voting results as an indication of public support for recreational harvest.

Results of voter referendums are often expected to represent how the general voter views an issue, but it is important to examine the role media coverage and framing have especially around controversial issues such as wolves and wolf management. Following the referendums, a content analysis was conducted to examine how wolves and wolf management were framed in the media during and around the time of the two wolf-related ballot initiatives in Michigan. Analysis by Gore (2016) found that in the three months prior to the election there were over 200 articles released by the media outlets. The dominant framing of these articles focused on public participation, wolf legislation, wolf policy, and wolf conflicts (what Gore categorizes as "power and control") and not on the Michigan Wolf Plan or general wolf biology. In a related study, Lute and Gore (2014) conducted semi-structured interviews with individuals reflecting a diverse set of stakes (e.g., animal rights, wolf advocates, deer hunters, legislators, livestock owners, trappers, tribal members, environmentalists, hunters who use dogs, animal welfare advocates, DNR biologists) and who had frequent involvement in the DNR public engagement processes leading up to the referendums (e.g., Wolf Management Roundtable, Wolf Forum, Wolf Management Advisory Council) to explore the relationship between knowledge and power relative to wolf management. Results from this study highlighted the concern stakeholders had for the role of special interest groups and the "undue influence on legislators because of their financial resources" (p. 5). Lute and Gore (2014) recommend avoiding single-issue framing of management issues in favor of reflecting diverse risks and benefits, as single-issue framing can increase perceptions of bias, which may ultimately result in stakeholders turning towards approaches such as ballot initiatives to mitigate perceived or actual bias (Loker & Decker 1995).

Trends in Public Support for Michigan's Wolves

Public attitudes in Michigan have been assessed prior to the 2021 survey, including in 2005 (Beyer 2006), 2004 (Mertig 2004), and 1990 (Kellert 1990). The Kellert survey occurred when wolves were beginning to re-establish in the Upper Peninsula (UP). When the Mertig survey was done, wolves were well established in the UP and down-listing them to threatened status was being initiated. In 2005, removal of wolves from the Federal endangered species list was being debated. These historical differences influenced the designs and outcomes of the surveys. Further, the Kellert and Mertig surveys looked at support for 'efforts' of wolf recovery and re-establishment, whereas the 2005 survey asked about approval of 'having wolves in Michigan.' The differences in history and in design of the questions require caution when comparing results to infer trends in Michigan-citizen support for wolves.

Kellert (1990) found that 64% of UP and 57% of Lower Peninsula (LP) respondents supported re-establishing timber wolves in the UP. By 2002, support may have decreased among UP respondents but remained somewhat constant among LP respondents. Mertig found efforts to help wolves recover in the UP was supported by 46% of UP, 57% of Northern LP (NLP) and 64% of Southern LP (SLP) respondents.

The 2005 survey revealed 41% of UP, 52% of NLP and 49% of SLP respondents strongly or somewhat approved of having wolves in Michigan. For the most recent 2021 survey, respondents were asked how they would like the wolf population to change in Michigan over the next five years. Similar to perceived past trends in the wolf population, there is a greater likelihood that people living in close proximity to wolves were more likely to desire a reduction in the wolf population. For the 2021 survey, results estimated 59.9% of UP residents want a decrease in the wolf population during the next five years, while those figures in the NLP and SLP are 25.1% and 16.7%, respectively. Only 15.3% of UP residents are estimated to desire an increase while the estimated percentages in the NLP and SLP who want an increase are 46.0% and 56.6%. Statewide, the estimated percentage of people who desire a reduced wolf population was 24.0%, 49.9% desire an increase, and 26.1% wish the population to remain the same.

Public Attitudes towards Wolves in Michigan

The 2021 survey of Michigan residents, deer hunters, fur harvesters, and livestock producers was conducted to assess the following public attitudes.

- Individuals' experiences with wolves.
- Perspectives on changing wolf populations.
- Beliefs about wildlife and wolves.
- Perceptions of risks related to wolves.
- Acceptability of wolves and various management strategies related to wolves.
- Engagement in outdoor activities and recreation.

In addition, data from this research allows for comparative assessments related to past Michigan wolf research (Beyer et al. 2006) and more recent studies in the Midwest (Holsman, Kaner, and Petchenik 2014; Schroeder et al. 2020).

Overview of the 2021 Survey Methods

Sampling

Questionnaires were distributed to 61,025 individuals including 15,000 residents, 22,909 deer hunters, 22,705 fur harvesters, and 359 livestock producers.

Our study sample is based on four separate groups of individuals with stakes in wolf management in the state of Michigan: the general public, deer hunters, fur harvesters, and livestock producers.

Deer hunters and fur harvesters. The sample of fur harvesters and deer hunters was drawn from the Department of Natural Resources Wildlife Division database of licensed hunters and trappers in Michigan. Our population of interest was defined as individuals who purchased a deer or fur license in the last five years in the state of Michigan and over the age of 18. To be included in our sample, individuals needed to provide an email address when purchasing their license. The number of licensed deer hunters in the database who purchased a license within the last five years (2015-2020) and were over 18 was 974,495; 371,841 of them provided email addresses; and we contacted 22,909 of for participation in this research. The number of licensed fur takers who purchased a license in the last five years (2015-2020) and were over 18 years old was 60,105; 33,459 of them provided email addresses; and we contacted 22,705 for participation in this research.

Livestock producers. Livestock producers were included in our sample based on a list provided by Michigan State University Extension of livestock producers in the state of Michigan. The list provided by MSUE included 359 individuals, and due to the small number of livestock producers for whom contact information was identified, all of them were contacted to participate in this study.

General public. We used a contractor to identify members of the general public for inclusion in the research; the contractor used a database of addresses based on USPS records for residents of Michigan. In consideration of present and projected wolf populations in the state of Michigan, we oversampled residents of the UP and NLP of the state. We contacted a total of 15,000 residents of Michigan to participate in this study. Of individuals in the resident population, 5,000 were distributed to people in the SLP of Michigan, 5,000 to people in the NLP, and 5,000 were distributed to residents of the UP. Of residents in the SLP, 1,000 were located in the Detroit metropolitan area (Wayne, Oakland, and Macomb counties), and of residents in the UP 500 were located in Marquette county.

For the purposes of this white paper, we focus most comprehensively on the results of the survey of the general public.

Data collection

The surveys for each of our stakeholder groups followed a modified version of the tailored design method (Dillman et al. 2009), however specific methods for contacting each varied based on differences in sample frames.

Hunter and fur harvesters*.* Data were collected via online Qualtrics surveys and individuals were contacted via email addresses that they provided during the deer or fur harvesting license buying process. Data were collected in August 2021 to October 2021, and individuals were contacted five times during that period via an email that provided them with a link to respond to our survey questionnaire.

Livestock producers*.* Livestock producers were contacted in two separate email processes. For the 308 individuals who did not respond to the initial requests to participate in this research effort, they were re-contacted from August 2021 to September 2021. Individuals were contacted four times during that period via email and directed to an online Qualtrics survey.

General public. Members of the general public were contacted via four waves of letters delivered by USPS from September 2021 - October 2021. The first two letters received by participants included a link to an online Qualtrics survey and instructions for how to access it by entering the link to the survey into a web browser. Members of the general public who participated in the questionnaire online were able to be identified via unique ID codes provided in those letters that were required to enter the Qualtrics survey. The final 2 mailings received by participants included paper copies of the survey in addition the link to the online Qualtrics survey. Mail back surveys included the same items as the online Qualtrics survey, and most items were formatted to be compatible with scantron data entry methods. Non-scantron compatible data were entered by individuals employed by the contract company. The company contracted to administer surveys also conducted a non-response check via telephone.

Weighting

Responses to the general public survey were weighted using post stratification weights based on demographic factors using the latest information from the US Census (MDHHS 2019). We weighted statewide data based on geographic region, gender, and age, for which data are provided at the county level, and we calculated marginal distributions for these factors at the level of the state. For data pertaining to specific regions, we weighted data based on gender and age. We trimmed weights calculated at the statewide level so no individual respondent was assigned a weight of < .2 or > 5; this was not necessary for weights calculated within regions. Weighting was done to improve the alignment between findings and the beliefs of Michigan residents. Prior to weighting data, missing data were imputed based on within-strata means, with strata based on gender, age, and region.

Response Rates

Adjusted response rates for the surveys were:

- General public survey: 20.26%
- Deer hunter survey: 20.01%
- Fur harvester survey: 31.44%
- Livestock producer: 32.68%

Results

The following contains a selection of results, reported from the general population survey only. These results reflect weighted data. Complete results tables for all populations surveyed are provided in Riley et al. (2022) and in the subsequent chapters of this paper. Only relevant results not reported in subsequent chapters are included in this chapter.

Experiences with wolves

A high proportion (96.7%) of Michiganders are aware that wolves exist in Michigan (Table 2-1). More than half have read or watched programs that featured wolves. Expected regional differences were apparent among those who had family or friends with experience with wolves; people who live in areas occupied by wolves have more experience with them. Nearly 52% of UP residents had family or friends with experiences compared to 31.1% among NLP residents and 23.2% in the SLP. Those regional differences were even more pronounced for people with direct experience themselves. For instance, 40% of UP residents have seen wolves in the wild on multiple occasions versus 6.8% in the NLP and 3.9% in the SLP.

Table 2-1 Experiences with Wolves

Which of the following best describes your personal experiences with wolves in Michigan?

Statement	UP Population	NLP Population	SLP Population	Total Population
I didn't know wolves existed in Michigan before I got this survey	0.2%	3.1%	3.4%	3.3%
I have read about wolves or watched programs that featured wolves	40.6%	53.3%	55.7%	54.4%
I have friends or family who talk about or had experiences with wolves in Michigan	51.8%	31.1%	23.2%	27.6%
I knew wolves lived in Michigan, but I have never seen or heard a wolf (captive or wild)	12.3%	41.7%	42.5%	39.3%
I have seen a wolf in captivity (zoo, educational facility)	44.8%	51.6%	57.6%	54.2%
I have seen wolf tracks in the wild	63.7%	23.3%	14.6%	21.8%
I have heard a wolf howl in the wild	64.4%	29.0%	21.3%	28.7%
I have seen game or livestock killed by wolves	27.8%	5.6%	4.4%	7.5%
I have seen a wolf in the wild once or twice	39.4%	21.9%	13.8%	18.2%
I have seen a wolf in the wild multiple times	40.0%	6.8%	3.9%	8.6%

Perceptions of risk

For the most part, perceptions of risk followed patterns related to where Michiganders reside in relation to wolves. Respondents from the UP consistently perceived greater risks, regardless of the type of potential risk, and the percentage of residents who perceived risks (especially “large amounts of risk”) decreased from the UP to the SLP. Extreme concerns (depicted as “large amount of risk”) about children, pets, hunting dogs, deer, and moose were more than two times greater among UP residents than those from the SLP. Risks to livestock were the most prevalent perceived risk regardless of residence. The least risk was perceived to personal property other than livestock or to the natural balance of Michigan’s ecosystems. Further discussion of risk results is presented in Chapter 4.

Attitudes toward wolves

Most Michiganders (80.2%) believe wolves have an inherent right to exist (Table 2-2). That belief is expressed fairly even across geographic regions in Michigan although the percentage of people who express that view are greatest in the SLP and decreases somewhat in the NLP and UP.

Table 2-2 Attitudes towards wolves

Statement: Wolves have an inherent right to exist.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	9.6%	6.3%	5.0%	5.8%
Moderately disagree	5.9%	1.7%	2.4%	2.3%
Somewhat disagree	5.2%	3.9%	1.9%	2.9%
Neither agree nor disagree	8.8%	10.0%	8.2%	8.8%
Somewhat agree	18.1%	12.1%	10.5%	11.9%
Moderately agree	12.7%	18.0%	12.9%	14.0%
Strongly agree	39.7%	47.9%	59.1%	54.3%

Statement: Wolves are an important part of ecosystems.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	9.6%	6.2%	3.9%	5.0%
Moderately disagree	6.1%	1.9%	2.7%	3.0%
Somewhat disagree	5.2%	2.7%	1.3%	2.2%
Neither agree nor disagree	8.4%	7.4%	5.6%	7.0%
Somewhat agree	18.8%	12.9%	11.4%	12.5%
Moderately agree	15.2%	21.0%	17.7%	17.7%
Strongly agree	36.7%	47.8%	57.6%	52.5%

Statement: Future generations will experience wolves in the wild.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	5.8%	3.5%	3.5%	3.8%
Moderately disagree	3.0%	1.6%	2.4%	2.9%
Somewhat disagree	3.3%	4.8%	3.4%	3.9%
Neither agree nor disagree	14.7%	20.4%	19.8%	18.5%
Somewhat agree	21.0%	20.8%	21.4%	21.7%
Moderately agree	19.5%	19.9%	15.5%	16.2%
Strongly agree	32.6%	29.0%	34.1%	33.0%

Statement: Wolves are a symbol of wilderness.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	9.5%	5.7%	3.4%	4.5%
Moderately disagree	4.5%	2.1%	2.0%	2.5%
Somewhat disagree	3.4%	2.7%	1.5%	2.4%
Neither agree nor disagree	15.6%	14.7%	10.6%	11.6%
Somewhat agree	19.5%	15.9%	14.7%	14.7%
Moderately agree	17.1%	18.5%	23.0%	20.8%
Strongly agree	30.4%	40.5%	44.8%	43.6%

Statement: I want to see or hear wolves in the wild.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	22.2%	9.7%	7.4%	9.1%
Moderately disagree	6.7%	4.6%	2.5%	4.0%
Somewhat disagree	6.9%	4.6%	3.6%	3.5%
Neither agree nor disagree	16.9%	16.2%	19.5%	19.1%
Somewhat agree	15.4%	17.6%	14.6%	15.3%
Moderately agree	10.3%	13.2%	16.8%	15.6%
Strongly agree	21.7%	34.2%	35.6%	33.3%

Statement: Wolves provide opportunities to hunt.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	22.2%	17.3%	25.7%	23.5%
Moderately disagree	7.1%	7.6%	7.5%	8.0%
Somewhat disagree	6.1%	8.9%	6.6%	7.0%
Neither agree nor disagree	27.8%	30.3%	34.4%	32.5%
Somewhat agree	13.4%	14.8%	11.5%	12.3%
Moderately agree	8.7%	7.2%	7.1%	7.2%
Strongly agree	14.6%	13.9%	7.2%	9.5%

Statement: Wolves provide an opportunity to trap.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	25.8%	25.6%	30.6%	28.7%
Moderately disagree	6.3%	5.3%	7.2%	6.2%
Somewhat disagree	6.9%	10.6%	8.6%	9.2%
Neither agree nor disagree	28.9%	31.1%	34.3%	32.6%
Somewhat agree	11.2%	11.2%	9.2%	10.1%
Moderately agree	7.7%	5.3%	3.5%	4.4%
Strongly agree	13.3%	10.9%	6.5%	8.7%

Statement: The presence of wolves improves my quality of life.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	32.8%	15.3%	9.5%	13.1%
Moderately disagree	7.5%	3.6%	4.8%	5.0%
Somewhat disagree	8.1%	7.1%	5.5%	5.6%
Neither agree nor disagree	27.0%	40.5%	43.5%	41.5%
Somewhat agree	6.8%	11.1%	11.2%	11.2%
Moderately agree	6.0%	9.7%	8.8%	9.1%
Strongly agree	11.9%	12.6%	16.7%	14.6%

Statement: Wolves contribute to the Michigan economy.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	29.9%	13.0%	8.3%	12.2%
Moderately disagree	10.1%	4.7%	3.4%	4.2%
Somewhat disagree	9.9%	6.0%	3.7%	5.0%
Neither agree nor disagree	28.5%	45.0%	49.4%	45.7%
Somewhat agree	8.3%	14.7%	12.8%	13.5%
Moderately agree	4.3%	6.8%	8.5%	8.1%
Strongly agree	8.9%	9.8%	13.9%	11.2%

Statement: Wolves are an important part of human culture.

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Strongly disagree	18.5%	9.2%	7.8%	9.9%
Moderately disagree	11.2%	4.8%	3.8%	5.3%
Somewhat disagree	5.9%	3.5%	3.3%	3.3%
Neither agree nor disagree	18.6%	22.0%	19.0%	19.0%
Somewhat agree	16.6%	22.6%	20.5%	20.4%
Moderately agree	11.1%	12.7%	17.2%	16.2%
Strongly agree	18.1%	25.0%	28.4%	25.9%

Perceptions of wolf population trends

Perception of trends in wolf populations varied throughout the State, yet a pattern was apparent that suggests those respondents living closest to existing Michigan wolf populations were more likely to believe that wolf populations had increased during the five years prior to the survey (Table 2-3; Figure 2-1). While 67.3% of the Michigan population was estimated to believe the wolf population had increased, 80.9%, 72.5%, and 62.4% of respondents in the UP, NLP, and SLP, respectively, reported the population had increased. Responses that indicated the wolf population had increased greatly over the last five years were reported by 36.6% of UP, 14.8% 0f NLP, and 9,0% of the SLP respondents.

Table 2-3 Perceptions of wolf population trends

Based on your experiences and perspectives, how do you think the wolf population in Michigan has changed during the past five years?

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Decreased Greatly	1.5%	3.7%	3.4%	3.3%
Decreased Moderately	3.0%	2.9%	8.0%	5.7%
Decreased Somewhat	3.8%	6.6%	8.1%	7.4%
Stayed about the Same	10.8%	14.3%	18.1%	16.4%
Increased Somewhat	21.5%	34.5%	33.6%	32.9%
Increased Moderately	22.8%	23.2%	19.7%	21.2%
Increased Greatly	36.6%	14.8%	9.0%	13.2%

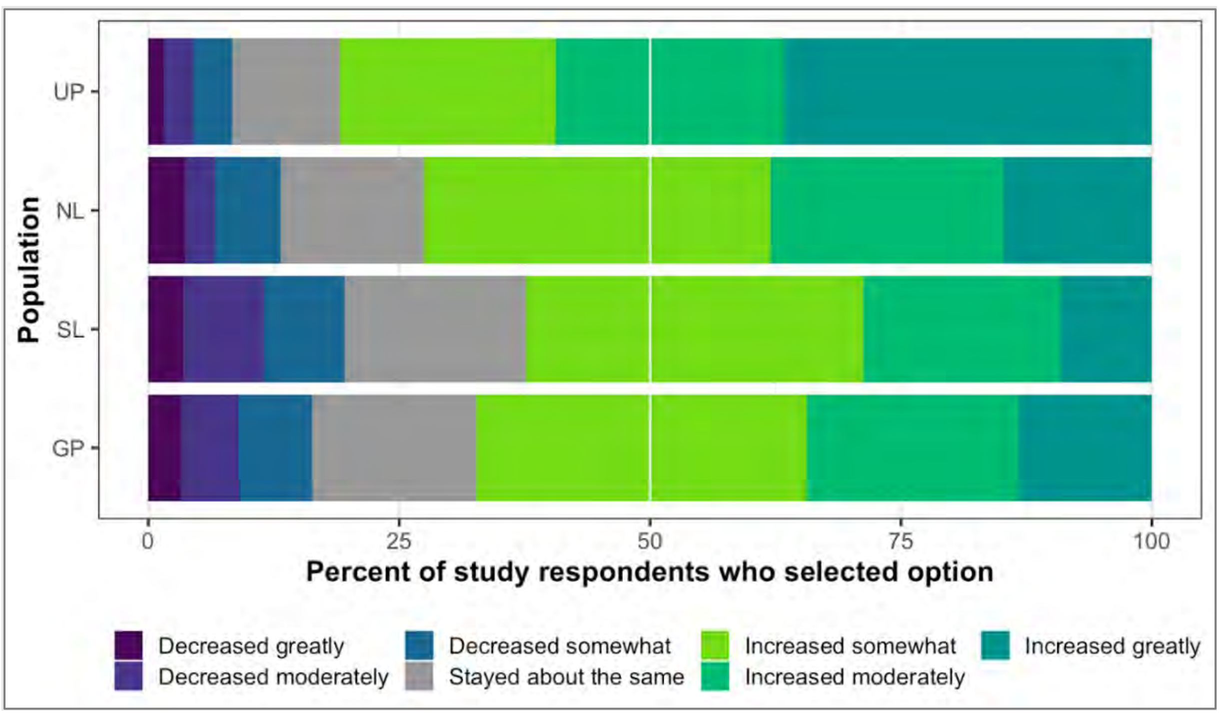

Figure 2-1 Based on your personal experiences and perspectives, how do you think the wolf population in Michigan HAS CHANGED during the past five years?

Desired trends in the wolf population

Similar to perceptions of past trends in the Michigan wolf population, there is a greater likelihood that people living in close proximity to wolves were more likely to desire a reduction in the wolf population (Table 2-4; Figure 2-2). An estimated 59.9% of UP residents desire a decrease in the wolf population during the next five years, while the estimates from the NLP and SLP are 25.1% and 16.7% respectively. Only 15.3% of UP residents expressed desire for an increase in wolf abundance while the percentage of respondents in the NLP and SLP who desire an increase are 46.0% and 56.6% respectively. Statewide, the estimated percentage of people who desire a reduced wolf population was 24.0% while 49.9% desire an increase.

Table 2-4 Desired wolf population trends

Based on your experiences and perspectives, how would you like the wolf population in Michigan to change during the next five years? (Question 7)

Sentiment	UP Population	NLP Population	SLP Population	Total Population
Decrease Greatly	29.4%	12.2%	6.9%	10.5%
Decrease Moderately	16.1%	6.0%	5.6%	7.1%
Decrease Somewhat	14.4%	6.9%	4.2%	6.4%
Remain the Same	18.8%	28.9%	26.7%	26.1%
Increase Somewhat	11.1%	24.0%	22.9%	22.2%
Increase Moderately	7.1%	15.7%	25.4%	20.8%
Increase Greatly	3.3%	6.2%	8.3%	6.9%

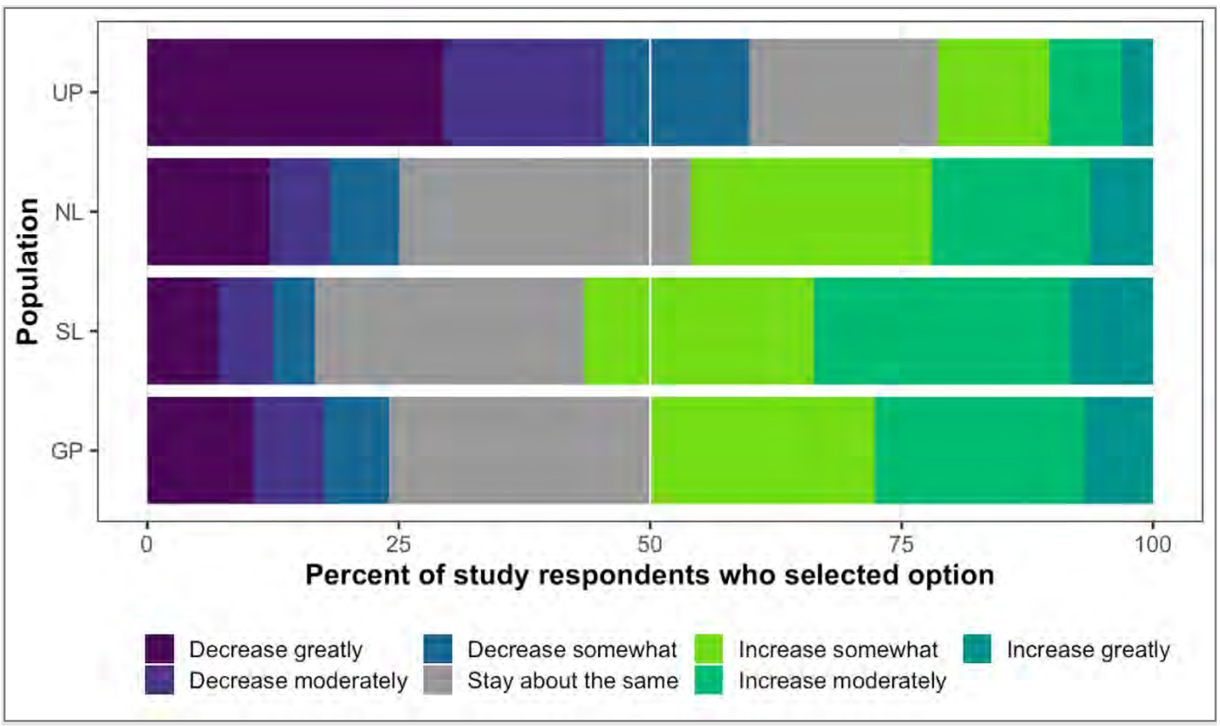

Figure 2-2 Based on your personal experiences and perspectives, how would you like the wolf population in Michigan TO CHANGE during the next five years?

Michigan residents were asked about acceptability of various qualitative scenarios of wolf populations: no wolves, very low numbers of wolves, moderately low numbers of wolves, moderate number of wolves, and greatest numbers of wolves that can be sustained. Neither no wolves, nor the greatest number sustainable, were acceptable among a majority of respondents (Figure 2-3). Across all regions, a scenario of moderate numbers of wolves appears to be acceptable to the most people (53.2%). A scenario described as "moderately low" is also estimated to be acceptable to 52.6% of respondents. A scenario of no wolves is estimated to be unacceptable to the vast majority (82.3%) and a scenario of the greatest number that can be sustained is estimated to be unacceptable to 54.0%. These findings suggest that management aimed at yielding moderate population levels may be desired by the majority.

Geographic differences in acceptability of population scenarios were evident. As population densities are difficult for individuals to comprehend, especially for a secretive organism like wolves, the results suggest people living closest to wolves want less frequent negative interactions. The scenarios acceptable to the greatest percentage of UP residents (55.6%) was moderately low wolf populations, followed closely in frequency by very low numbers of wolves (54.3%). For residents of the NLP, the scenario most frequently identified as acceptable is "moderately low." For SLP residents, the most acceptable scenario was "moderate" numbers. Although UP residents chose moderately low, nearly 65% indicated that "no wolves" was an unacceptable outcome; in comparison 79.7% of NLP residents and 86.4% of SLP residents indicated no wolves was acceptable.

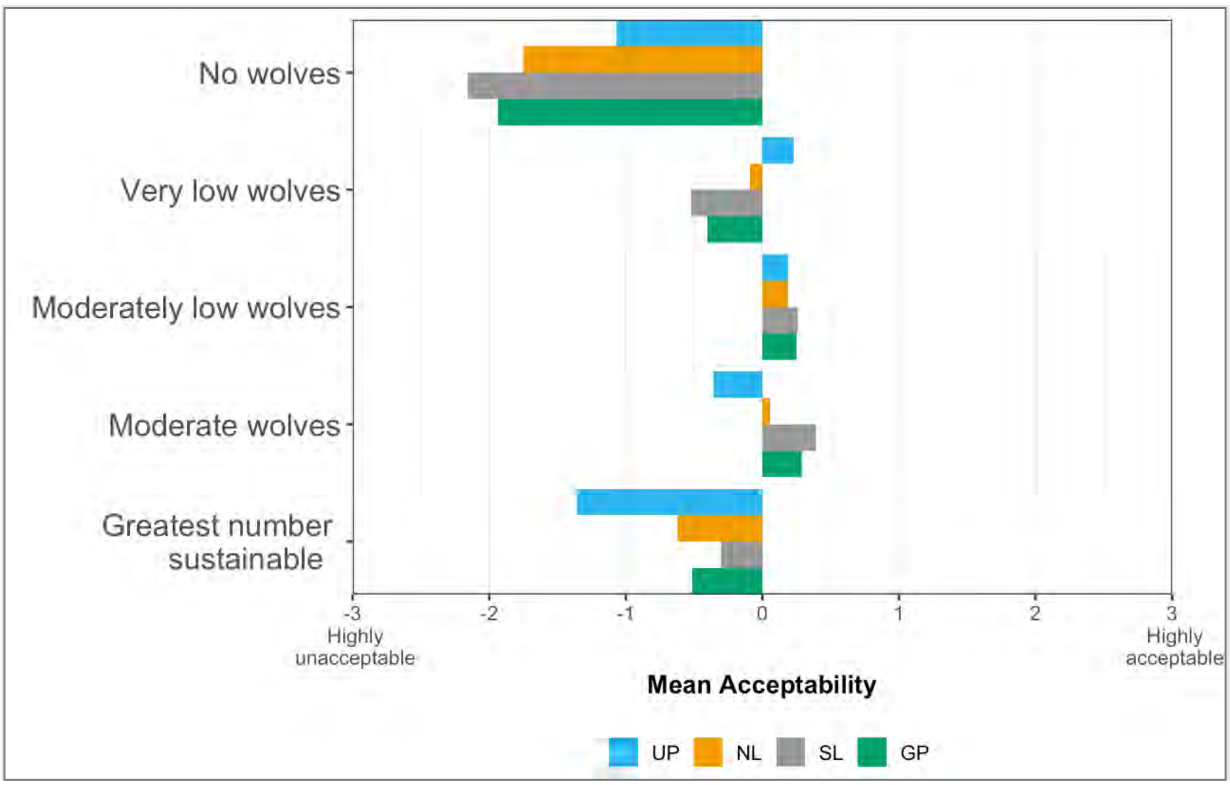

Figure 2-3 Acceptability of wolf population scenarios

Wolves in the Northern Lower Peninsula

A preponderance (66.0%) of people in Michigan believe it is acceptable if wolves were to establish a population in the NLP (Figure 2-4). The greatest frequency of people who believe it to be acceptable reside in the SLP. Residents in the UP and NLP expressed similar proportionality of acceptability of wolves in the NLP. A slight preference to not have wolves within their region of residence was expressed by NLP respondents in that they were the region who had the greatest proportion of responses as “unacceptable.” This result is consistent with the other findings that indicate those residents living with wolves are least likely to be accepting of wolves.

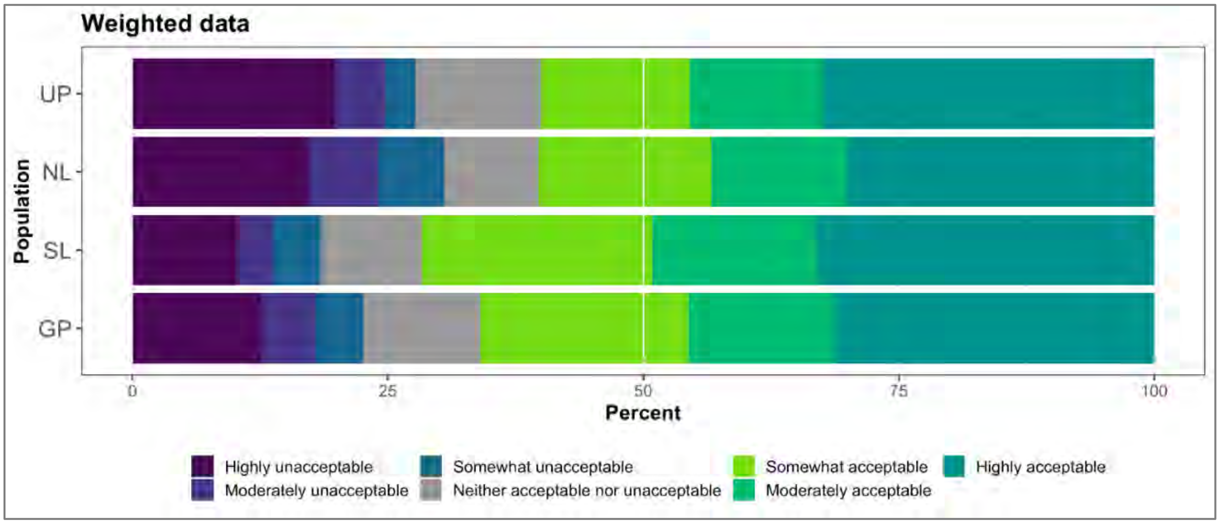

Figure 2-4 Acceptability of wolves establishing a population in the Northern Lower Peninsula.

Chapter 3 Managing Wolf Population Size and Distribution

Executive Summary

Management of wolf population size and distribution is complex, both biologically and socially. The number of wolves that must be treated or removed to achieve a given set of population goals is determined by the interplay of many biological factors. Moreover, methods of population management are often controversial. Managers must consider both biological and social consequences when making decisions regarding goals and techniques for population management.

Non-lethal methods of population control include fertility control and relocation. Fertility-control techniques include surgical sterilization and non-surgical contraception. These techniques have been proven effective for small-scale predator management in some cases. However, they are associated with several limitations, such as undesirable side effects, high cost, and difficulty in identifying and treating breeding individuals in a pack. Fertility control has not yet been proven as a feasible or effective technique for large-scale wolf population control. Relocation/translocation may be a practical method to reduce the number of wolves in areas where populations are small. However, several limitations are associated with this technique: (1) animals may return to their original capture locations; (2) translocated animals may cause new problems in the areas surrounding their relocation sites; (3) animals may be moved into another pack's territory and be killed as trespassers; (4) suitable unoccupied areas may not be available; and (5) adequate public support is necessary for successful translocation. For these and other reasons, relocation/translocation of wolves in Michigan would be challenging.

Lethal methods of population control have historically included trapping, snaring, shooting (from the ground or air) and poisoning. These techniques influence population size by increasing mortality rates. Research indicates an average wolf population could be expected to stabilize when annual wolf mortality (excluding pups) reaches approximately 34%. However, populations vary greatly in the level of mortality they can sustain. The level of mortality required to effectively control a population is determined by many factors, such as population size (current and desired), age and sex structure, immigration and emigration rates, birth rates, and natural and human-induced mortality rates. Moreover, wolf mortality is often compensatory, meaning human-induced mortality can sometimes replace mortality that would otherwise occur due to natural factors, such as starvation, disease, or intraspecific aggression.

Public wolf harvests occur in Canada, Alaska, and areas of Europe and Asia. In these areas, hunters and trappers annually removed as much as 28% of the wolves in an area (e.g., Adams et al. 2008), but the populations appeared to remain stable or to increase. However, comparisons between wolf harvests in other areas and a potential public wolf harvest in Michigan are more complex. Differences in the number of people, access, habitat conditions, and social acceptance limit the utility of such comparisons.

In addition to public harvest, wolf control programs have been carried out by government agencies in Alaska and Canada to reduce wolf numbers in specific areas. The primary purpose of these control programs has been to allow populations of ungulates species to increase, often to increase potential human harvest of ungulates. Effectiveness of those programs was somewhat equivocal; increases in ungulate populations were measurable only when wolves were reduced over large areas for multiple years. Changes in ungulate populations following cessation of wolf control often were not monitored.

The use of poison and bounties was historically effective at controlling, and often eradicating, wolf populations. Today, however, these techniques are not considered to be biologically sound, socially acceptable, or financially feasible.

An alternative to active management of wolf population size and distribution is passive management. Under such an approach, wolf populations would be allowed to increase to the maximum number the habitat could support. As populations approached biological limits, natural checks on wolf numbers, such as starvation and disease, would likely increase. Large die-offs due to disease during periods of stress, such as winter, would be possible. No effort would be expended to control population size. However, this approach may require more agency resources for managing wolf–human conflicts. Acceptability of management actions depends on the nature of the interactions with humans that creates a need for management interventions. The 2021 survey presented five scenarios of increasing expected intensity of human-wolf interactions and asked about the acceptability of six management actions, also of varying intensity. The only interaction that elicited acceptability by the majority for killing wolves was attacks on humans. Passive management, or a "do nothing" alternative was the least acceptable action for every situation.

If one or more wolves had to be removed from an area for some reason, the most acceptable method among four choices was "provide a limited number of permits to licensed hunters to shoot wolves during a controlled hunt" (68.3% statewide). This method of removal was least favored in the SLP and most favored in the UP. The least acceptable means of removal was to "kill wolves that are trapped by trained, paid professionals" state-wide and among all regions. These findings are generally similar to the results of the 2005 public attitudes survey. Patterns of public support for management of wolf numbers and distribution were tied to the method being proposed. In the weighted sample of interested citizens from the 2005 survey, use of licensed hunters (approximately two-thirds supported) and trappers (60% supported) to remove wolves received the greatest support whereas use of trained, paid professionals to shoot (38% supported) or trap (26% supported) wolves received the least support.

Introduction

History shows that wolf populations can be controlled, even eliminated, through human actions. The use of poison is believed to be the primary mechanism that allowed the extermination of wolves from many parts of their range throughout the world (Boitani 2003). In the territory that eventually became the United States, the hatred and killing of wolves by European settlers was fueled by the desire for territorial conquest, agricultural settlement, and livestock production, and further supported by European folklore (Coleman 2004). More recently, it has been shown that wolves appear resilient, and populations can grow quickly with protection and sufficient prey (e.g., Wydeven et al. 1995, Wabakken et al. 2001, Webb et al. 2011). For example, using simulation models, wolf population size was estimated to reach recovery goals in the State of Washington in 12 years (Maletzke et al. 2015).

As wolf populations have recovered, wolf–human conflicts have occurred (e.g., Ruid et al. 2009, Edge et al. 2011a, Fowler et al. 2019). In some cases, these conflicts can be addressed by changing the behavior of or removing individual wolves. In other instances, reducing the size and/or growth rate of a wolf population with non-lethal or lethal methods has been proposed as a management strategy.

Wolf population control is beset by many issues, both social and biological in nature. For example, killing wolves to control population size is a controversial and contentious issue that often polarizes stakeholder groups interested in wolf conservation and management. Controlling a wolf population is also biologically complex. The number of wolves that must be treated or removed for effective control is determined by many factors, such as population size (current and desired), age and sex structure, immigration and emigration rates, birth rates, and natural and human-induced mortality rates.

If managers are presented with the necessity of controlling wolf populations at some level, they will need to understand what proportion of the population to remove or treat, the frequency that control actions are needed, which method(s) will be used, and what areas will be subject to the control actions.

This chapter provides background on management options that may be considered for controlling wolf population size and distribution. It provides a review of recreational wolf harvests and control programs that have occurred in North America as well as other parts of the world. It also addresses the social issues surrounding wolf population control and summarizes the current understanding of Michigan stakeholder attitudes towards wolf population control options.

Non-lethal Control

Population control methods are usually categorized as non-lethal or lethal. Non-lethal methods include prevention techniques such as guard dogs, harassment, relocation.

Fertility Control

The public often perceives fertility control as more humane than lethal control. Research suggests sterilization does not influence the basic social and territorial behavior of wolves; sterilized dominant wolves continue to maintain pair bonds and retain their dominant status. Thus, sterilizing alpha wolves may slow wolf population growth. Two methods are most often used to control the fertility within a wolf population: surgical sterilization and non-surgical contraception.

Surgical sterilization

Limited recent research has been conducted regarding application of surgical sterilization for management of free-ranging wolf populations. Previously, a study across eastern interior Alaska and the Yukon Territory assessed whether non-lethal wolf-management techniques could help restore the Fortymile caribou (*Rangifer tarandus*) herd. The management plan called for sterilization (vasectomies and tubal ligations) of the alpha pair in up to 15 packs over 3 years and translocation of remaining pack members to locations at least 100 miles away (www.wildlife.alaska.gov). Between November 1997 and May 2001, wolf numbers were reduced in 15 packs and the Fortymile caribou population doubled in size (www.wildlife.alaska.gov).

In Utah, Bromley and Gese (2001a, b) studied the effects of sterilization on the social and sexual behavior of coyotes (*Canis latrans*) and whether sterilization would modify coyote predatory behavior and reduce predation on sheep. Their results indicated sterilization had no effect on pair-bond maintenance and territorial behavior among free-ranging coyotes (Bromley and Gese 2001b); thus, sterile coyotes could remain in the territory and exclude other, sheep-killing coyotes (Bromley and Gese 2001b). Because the study sterilized as many pack members as possible, no data exist on whether non-sterile pack members would reproduce/replace the sterile alpha pair. Bromley and Gese (2001a) indicated that coyotes change their predatory tendencies when pups are present because of the need to provide them with food. Based on the results that sterile coyotes maintained pair bonds and territories and had higher survival rates, a sterile coyote pair could prove to be a viable small-scale management tool to reduce coyote predation on sheep (Bromley and Gese 2001a, b).

Spence et al. (1999) conducted a fertility-control study in Aishihik, Yukon within a free-ranging wolf population. Their objective was to determine whether surgical sterilization of breeding pairs altered their social and territorial behavior. Six male and seven female wolves were sterilized via vasectomies and uterine horn ligations, respectively. These sterilization techniques were chosen because they do not induce changes in hormonal cycling and therefore do not alter social and sexual behavior. Two female wolves died as a result of surgical complications. All surviving sterilized wolf maintained their pair bonds and remained in their territories. One sterilized wolf pair produced a litter of one pup; the male in this pair was not sterilized and the female may have already ovulated and bred before her ligation (Spence et al. 1999). Two lone treated wolves met and formed a pair bond during the denning season. Spence et al. (1999:120) indicated that "sterile wolf pairs, which can continue to hunt together because the females are not confined to the den, will have less of an impact than larger packs upon caribou and moose calves." The researchers suggested surgical sterilization represents an alternative to lethal control for small-scale wolf management (Spence et al. 1999).

From 1987 through 1994, Mech et al. (1996) conducted a male wolf sterilization study in the Superior National Forest in northeastern Minnesota. Uterine ligations were not performed during this study due to the complex nature of the surgery. Five male wolves were live-trapped, transported to a veterinary lab, and surgically vasectomized (Mech et al. 1996). The wolves were observed for 1, 3, 4 and 7 years post-vasectomy; in all years, the pack size remained the same or decreased and all vasectomized wolves remained in their territories. Sterilizing wolves that cause chronic depredation may reduce the local wolf population by two-thirds, thereby reducing depredations (Mech et al. 1996).

A simulation model of wolf dynamics was developed to predict the population effects of different wolf-sterilization and removal strategies (Haight and Mech 1997). The results suggest the effects of sterilization and removal depend largely on annual immigration rates. With low immigration, periodic sterilization reduced pup production and resulted in lower rates of territory re-colonization. Average pack size, number of packs, and population size were significantly smaller than for a non-sterile population. Similar results were observed when periodically removing a proportion of the population; however, more than twice as many wolves had to be removed than sterilized. With high immigration, periodic sterilization decreased pup production but not territory re-colonization and produced only moderate reductions in population size.

Bromley and Gese (2001b) estimated the cost of surgically sterilizing a coyote to be $560 per animal. Till (1982) estimated that locating and removing one den of coyote pups costs $208. Wagner and Conover (1999) estimated that it costs approximately $185 to kill a coyote from an aircraft and about $805 to trap a coyote on the ground. Bromley and Gese (2001b) suggested that on a small-scale livestock operation (experiencing depredation by only one pack), the cost to surgically sterilize one coyote pack was recovered by the amount of losses averted within the same year. Cost estimates for wolf-sterilization activities remain unavailable.

Non-surgical contraception

Injecting a chemical sclerosing agent into the ductus deferens of a male wolf is one non-surgical contraception technique. This technique shows promise in domestic dogs, but more research is needed

(Spence et al. 1999). During non-surgical female contraception, an immunocontraceptive drug blocks fertilization. The drug allows the body to produce antibodies that prevent sperm from implanting (Fayrer-Hosken et al. 2000). Gardner et al. (1985) administered oral contraceptives to five captive female wolves, resulting in controlled estrus and sterility; however, young wolves exhibited increased aggression. Immuno-contraception also has been suggested to potentially reduce disease risk and transmission in relation to feral domestic dogs (Massei et al. 2010).

Fertility-control limitations

Spence et al. (1999) noted that all reported immunocontraception of canids was associated with undesirable side-effects. The effectiveness of fertility control has not been established for large-scale population management. Several inherent difficulties are associated with fertility control, including accuracy in identifying the dominant breeding pair in a pack and the changing nature of pack hierarchies. Sterilization also requires surgery, and this technique is not viable as a widespread management method.

Relocation/Translocation

Translocation may be a practical method of removal when a wildlife population is small and each individual is important to the survival of the species. Nuisance wildlife is sometimes translocated to new areas in hopes it will not cause similar damage. Several limitations are associated with translocating wildlife: (1) animals may return to their original capture locations; (2) translocated animals may cause new problems in the areas surrounding their relocation sites; (3) animals may be moved into another pack's territory and be killed as trespassers (Sillero-Zubiri and Switzer 2004); and (4) other wolves from surrounding packs may rapidly repopulate an area where a wolf was originally removed (Bjorge and Gunson 1985) and may cause additional problems. Additional considerations include whether there are suitable unoccupied areas for translocation and if there is adequate public support necessary for successful translocation.

Release sites are often based on the size and suitability of public lands in an area, distance from farms, and whether the area already contains wolf packs. Experiments on translocated wolves in Minnesota indicated wolves must be moved at least 45 miles or they will return to their capture area (Fritts et al. 1984). In the study area, translocation was largely unsuccessful at keeping problem wolves out of livestock production areas (Fritts et al. 1984).

In some States, wolves are translocated to new areas following confirmed livestock depredations. Research in the northwestern United States suggests translocated wolves depredate again near their release site and often attempt to return to the capture site (Bradley et al. 2005). Bradley et al. (2005) concluded that translocation was ineffective at meeting wolf-management objectives. Using data from Bradley et al. (2005) in a synthesis evaluating efficacy of methods to mitigate livestock depredations. Bruns et al. (2020) found that translocation was less effective compared to non-lethal deterrents.

In Michigan, trapping and translocation has become increasingly problematic. None of the 24 wolves trapped and relocated from five depredation sites has remained in the vicinity of the release sites. As the wolf population increases, there are fewer suitable places to release wolves where a resident wolf pack does not already exist (B. Roell, Michigan DNR, personal communication).

Lethal Control

Lethal methods include trapping, snaring, shooting (from the ground or air) and poisoning. Depending on the nature of specific control programs, lethal methods could be used by government agencies, the public, or both.

Mortality Required for Effective Control

The growth of any population, including wolves, is dependent on the interaction of the rates of reproduction, mortality, immigration and emigration. From a wolf-management perspective, the rate of mortality is the factor over which managers can exert the most control.

Wolves are prolific, with litters averaging 4–7 pups across much of their range (Mech 1970, Fuller et al. 2003, Ferreras-Colino et al. 2010). But wolf litter sizes can be greater based on wolf density, with lower density populations having larger litter sizes (Sidorovich et al. 2007). As a result, wolf populations can remain stable or increase despite relatively high mortality rates (Fuller 1989, Mech 2001, Adams et al. 2008, Creel and Rotella 2010).

Annual mortality tends to fluctuate from year to year and can be compensatory (Fuller et al. 2003, Mech 2001, O'Neil 2017). That is, human-induced mortality can sometimes replace mortality that would otherwise occur due to natural factors, such as starvation, disease or intraspecific aggression (Fuller et al. 2003). Natural mortality of eastern wolves near Algonquin National Park increased following cessation of legal human harvest (Rutledge et al. 2010). For example, Adams et al. (2008) analyzed North American wolf populations and found that wolf population trends were not associated with levels of human-caused mortality <29%, due primarily to local dispersal, emigration and immigration. In contrast, in a meta-analysis using data from 21 wolf populations in North America, Creel and Rotella (2010) suggested human offtake could be additive or result in super-additive increases in total wolf mortality. However, Creel and Rotella (2010) also concluded that wolves can be harvested sustainably within limits. In a reanalysis of these same data considering data limitations and improved modeling, Gude et al. (2012) determined that the predictions for declining wolf populations reported by Creel and Rotella (2010) were not supported. In Wisconsin, human-caused mortality likely needs to exceed 23-24% for the wolf population decline to occur (Stenglein 2014, Stenglein et al. 2018).

Studies in Minnesota and Denali National Park, Alaska, where wolves are not harvested, reported that approximately 10% of the wolves in each population were killed by other wolves (Mech 1977a, Mech et al. 1998). By contrast, in areas of Alaska where wolves were legally harvested, mortality due to intraspecific aggression was much lower (Peterson et al. 1984, Ballard et al. 1987, Ballard et al. 1997). This comparison supports the conclusion that mortality caused by other wolves can be compensatory to that caused by harvesting (Mech 2001). The wolf population in and near Denali National Park, Alaska, did not experience short- or long-term changes in population dynamics from harvest levels of wolves near the park; wolves were suspected to be resilient to this mortality source (Borg et al. 2015, 2017).

While excluding mortality of pups from birth through autumn, Fuller et al. (2003) estimated that, on average, a wolf population can be expected to stabilize when the total annual mortality rate is 0.34 ± 0.06 SE, or when the human-induced annual mortality rate is 0.22 ± 0.08 SE. However, the effects of human-induced mortality can vary substantially among populations (Gasaway et al. 1983, Peterson et al. 1984, Ballard et al. 1987, Fuller 1989, Lariviere et al. 2000, Hayes et al. 2003). In north-central Minnesota, a wolf population experiencing a human-induced mortality rate of 29 percent was found to be stable or increasing (Fuller 1989). In Alaska, a wolf population declined after harvests ranging from 42 to 61%, but increased by 58% following a take of 32% (Peterson et al. 1984). In Quebec, a population remained stable while facing a sustained harvest of 74%; this population was apparently maintained by immigration (Lariviere et al. 2000). Several other studies have shown that wolf populations can sustain annual winter harvests of 28–47% without permanent declines in their numbers (Mech 1970, Ballard et al. 1987, Ballard et al.1997). Sources of variation include the age and sex structure of the population, the degree of compensation among mortality factors, reproductive status of harvested animals, time of mortality, and the rates of reproduction, immigration and emigration (Fuller 1989, Fuller et al. 2003, Adams et al. 2008, Borg et al. 2015). In addition, some variation is the result of measurement error and/or the analysis technique used.

Annual mortality rates of radio-collared wolves in the Upper Peninsula averaged between 0.13 and 0.32 from 1997 through 2012 (O'Neil et al. 2017). It is important to note that these mortality estimates may be, to an unknown degree, biased because captured wolves were vaccinated for a variety of diseases and treated for mange prior to 2004. This practice may have reduced the amount of natural mortality observed before 2004.

Additional Impacts

Although wolf populations are able to recover numerically from human-induced reductions, harvest may impact wolves in ways that are less obvious than changes in population size. Wayne (1996) indicated kinship ties affect social stability and pack persistence. Lehman et al. (1992) found, compared to two protected populations, a heavily harvested population exhibited fewer kinship ties and showed a more rapid rate of genetic turnover, similar to Rutledge et al. (2010) for eastern wolves. Rick et al. (2017) suggested that anthropogenic harvest in Minnesota has a non-negligible effect. Although Rick et al. (2017) found no differences in genetic heterozygosity and allelic richness, they noted population genetic structure increased and effective migration decreased among wolves sampled, and recommended additional studies to better understand the effects of harvest on population structure and gene flow (Rick et al. 2017). Harvest may also affect age structure of a wolf population. In Denali National Park, where the population is protected, wolves often live 7–10 years (Haber 1996). By contrast, wolves rarely live more than 5–7 years in harvested populations (Stephenson and Sexton 1974, Hayes et al. 1991). Few wolves harvested during the 2012 and 2013 Minnesota wolf harvest seasons were >6 years old (Stark and Erb 2013, 2014).

Santiago-Avila et al. (2020) reported increased prevalence of unreported poaching of wolves in Wisconsin during periods of policy change providing increased use of lethal wolf control in defense of human property or safety, though it is not possible to quantify poaching that is not documented. However, Olson et al. (2015) demonstrated that poaching of radio-collared wolves declined in association with lethal control in Wisconsin. Chapron and Treves (2016a,b) attributed reductions in wolf population growth in Wisconsin and Michigan during periods of state authorized legal control to poaching. However, multiple research teams countered this assertion from multiple conceptual, biological, and analytical perspectives (Olson et al. 2017, Pepin et al. 2017, Stien 2017) to which the original authors were provided opportunity to respond (Chapron and Treves 2017a, b). Further research is needed to understand the relationship between poaching levels and management policies.

Public Harvest

Prior to the 1970s, wolves in North America were hunted and trapped with few restrictions. Throughout much of their histories, Native Americans have hunted and trapped wolves over most of the continent (Nelson 1983). Some authors believe aboriginal peoples hunted wolves as a way to enhance ungulate populations (Berkes 1999). Following European settlement, year-round seasons and non-existent bag limits were typical in both Canada and the United States. Few provinces, territories or states required registration of wolf pelts, and numbers harvested were roughly estimated at best. Where recreational harvest figures are available, they typically do not include those animals taken by subsistence hunters in Alaska or First Nation members (indigenous peoples) in Canada.

Since the 1970s, when wolves became legally protected in the lower 48 States, legal recreational harvest of wolves in North America has generally been restricted to Alaska and most provinces of Canada (Hayes and Gunson 1995, Musiani and Paquet 2004). However, when wolves were removed from listing under the Endangered Species Act, legal harvests occurred in Minnesota, Wisconsin, and Michigan during the period 2012-2014. Further, following federal delisting in 2021, Wisconsin held legal wolf harvest in February 2022. Legal recreational harvest also occurs in several Western Europe and Eurasian countries. The following text summarizes regulations, levels of take, and population impacts associated with recent recreational harvests of wolves in various parts of the world.

Canada

Throughout Canada, First Nations members may hunt and trap wolves without restriction. Other residents require licenses for hunting and trapping according to regulations set by individual provinces and territories. Resident hunters in the Northwest Territories may take wolves under a general resident license, whereas resident hunters in Yukon, British Columbia and Manitoba may take wolves under big game licenses, and resident hunters in Labrador, Quebec, and Ontario may take wolves under small game licenses. Ontario resident hunters are required to have an additional wolf tag to hunt in specific areas. Resident hunters in Saskatchewan may take wolves under a specific wolf license, and Alberta residents do not need a license to take wolves. Most Canadian provinces and territories do not charge special fees or require hunting tags or seals for wolves. In general, wolf trapping is allowed in Canadian provinces and territories under a trapping license. Where harvest is allowed, wolves may be taken by foot-hold traps, snares or shooting.

Statistics on wolf hunting are not compiled throughout much of Canada. Better data are available for trapping harvest levels. Yukon requires pelt sealing for commercial sale. In other areas, trapping harvest is tracked using records from auction sales or trapper questionnaires.

In 1995, Hayes and Gunson (1995) reported hunters and trappers took approximately 4,000 wolves annually, representing an estimated 4–11 percent of the population. In most areas, trappers took more wolves than did hunters. Between 1983 and 1990, however, the number of wolves taken by trappers declined by 40 percent (Hayes and Gunson 1995).

In 1995, wolf population size in Canada was estimated to be 52,000–60,000 wolves (Hayes and Gunson 1995). Changes in local wolf densities appeared to be influenced primarily by prey availability (Hayes and Gunson 1995). Theberge (1991) indicated that, outside of extreme southern Canada where large human populations occurred and harvest effort was concentrated, recreational harvest did not appear to be limiting the wolf population. In the ten territories or provinces where the wolf was classified as a game species, six of the populations were considered stable whereas four were considered increasing in the year 2000 (Boitani 2003). During 1994-2004, an average of 2,450 pelts were sold in Canada, representing typically less than 10% of the total population each year (Government of Canada 2014). Based on annual birth rates for wolves, the annual harvest in Canada is considered sustainable (Government of Canada 2014). In 2010, the wolf population in each of the 10 Canadian territories or provinces where wolves occur and are harvested was considered secure (Government of Canada 2014). The sustainable harvest of wolves remains legal throughout most of Canada (e.g., Government of British Columbia 2020, Alberta Government 2021, Province of Ontario 2022).

Alaska

In Alaska, permissible wolf-harvest methods have fluctuated since the 1970s (Alaska Department of Fish and Game 2005). Previously, wolves were taken by recreational trappers during trapping seasons which averages 6 months, with no bag limit. Snaring is allowed and is often the method preferred by trappers in many parts of Alaska (Scott and Kephart 2002). Wolves may be taken as trophy animals and are often harvested incidentally by hunters pursuing other species, such as moose and caribou. The harvest season for wolves was up to 6 months (1 November to 30 April) with no limit. The State of Alaska has since liberalized hunting methods, particularly for those management units selected for wolf control. Use of snowmobiles are currently allowed and land-and-shoot hunts have been previously allowed in some areas. Aerial gunning and land-and-shoot hunts are used specifically in areas where the goal is to reduce wolf population size as part of Alaska's predation control program but are considered wolf control and not a form of hunting or trapping.

Hunters and trappers typically take about 1,200 wolves per year during 1999-2020 (Alaska Department of Fish and Game; unpublished data) and in the most recent reporting year (July 2020-June 2021), with 1,168 individuals sealed, wolves ranked as the third most important furbearing species in Alaska (Bogle 2021). This level of take, which is low relative to the maximum legal harvest, may be due to the limited road access and extreme winter conditions throughout much of Alaska during the wolf season. At the current level, an estimated 17–28 percent of the population is harvested annually. In 2000, the wolf population, which consisted of 6,000–7,000 animals, was considered to be stable or increasing (Boitani 2003). Currently, the Alaska Department of Fish and Game estimates 7,000-11,000 wolves statewide (Alaska Department of Fish and Game 2022).

Great Lakes States

Minnesota has the largest wolf population of the Great Lakes states, estimated at approximately 2,700 wolves in 2019–2020 (Erb and Humpal 2020). Minnesota held hunting and trapping seasons during 2012–2014 following federal delisting in 2011. The total harvest of wolves during those years was 413 in 2012, 238 in 2013, and 272 in 2014. Following the most-recent wolf delisting in 2021, officials in Minnesota delayed official consideration of a public harvest until after the state's wolf management plan is updated. Wisconsin has an estimated wolf population of 1,195 wolves (Wiedenhoeft et al. 2020). Wisconsin also held wolf hunting and trapping seasons during 2012-2014, with a total wolf harvest of 117 in 2012, 257 in 2013, and 154 in 2014. Following wolf delisting in 2021, Wisconsin held an additional hunting and trapping season during February of 2021 that resulted in the harvest of 218 wolves. A wolf hunting season in Wisconsin is required by statute when wolves are not federally listed as threatened or endangered. During periods when hunting is allowed, hunters in Wisconsin can pursue wolves with the aid of calls, bait, traps, and dogs. Michigan held a single hunt from November 16th to December 31st, 2013 in three areas of the Upper Peninsula; 23 wolves were harvested.

Western States

The wolf population in western states was 3,500 or more in 2020. Harvest management has varied across these states over the past two decades. For example, the Montana Wolf Management Advisory Council through Montana's Wolf Conservation and Management Plan (2000) offered the following guiding principle with regard to recreational harvest: "Opportunities for regulated public take of wolves through hunting and trapping should be provided as wolf numbers increase, but opportunity should also be consistent with sustaining viable wolf populations into the future, thereby precluding reclassification under Federal law." Accordingly, the Montana Fish, Wildlife and Parks Department provides opportunities for a regulated wolf harvest following Federal delisting of the species. In Montana, the wolf population was about 1,400 individuals in 2011. From 2012-2019, 242 wolves were harvested annually on average, with 327 wolves harvested in the 2020 season (Inman et al. 2020). During the most recent (4 September 2021-15 March 2022) wolf hunting and trapping season in Montana, 273 wolves were harvested. The wolf population has been stable from 2011-2020 at about 1,100 individuals (Inman et al. 2020).

The Idaho Wolf Conservation and Management Plan (Idaho Legislative Wolf Oversight Committee 2002) included provisions for a regulated public harvest when the number of wolf packs exceeds a certain level. Hunting quotas were initially established to manage distribution of wolf harvests through 2016, after which harvest quotas were removed statewide (Idaho Fish and Game 2022). In 2009, 181 wolves were harvested in Idaho and harvests then declined from 377 in 2011 to 249 in 2014 (Ausband 2016), then to 226 wolves in 2016 (Hayden 2017). During the 2019-2020 season, 570 wolves were harvested. The Idaho Game and Fish Commission in 2021 expanded wolf seasons and methods of take to reportedly reduce wolf conflicts with livestock and elk (Idaho Fish and Game 2022). The 2021-2022 wolf hunting and trapping season was year-round (1 July-30 June) with no daily or season limit (Idaho Fish and Game 2021). Currently, about 1,543 wolves occur in Idaho and the population has been stable since 2019 (Idaho Fish and Game 2022).

Under the current Wyoming Gray Wolf Management Plan (Wyoming Game and Fish Department 2003), wolves are to be classified as either trophy game animals (regulated harvest) or predatory animals (unregulated harvest), depending on population levels and region of the State. Harvests in Wyoming are considerably less than harvests in Montana and Idaho, with 42 wolves harvested in 2012, 24 in 2013, 44 in 2017, and 33 in 2020 (Wyoming Game and Fish Department 2022). In 2020, the Wyoming wolf hunting season was year-round with a limit of 1 wolf per license during each calendar year and individuals were able to purchase 2 licenses each calendar year (Wyoming Game and Fish Commission 2020).

Other western states with wolves have had either limited jurisdiction to consider public harvest within the state (e.g., Utah), do not have a resident wolf population such that few wolves have been harvested (e.g., South Dakota), or had small wolf populations and did not authorize a harvest season (e.g., Oregon, Washington).

Spain, Poland and Russia

The wolf population in Spain included approximately 2,000 animals in the year 2000 (Boitani 2003) and is apparently stable, with about 2,500 individuals in the Iberian region population (Boitani 2018) of which about 80% occurs in Spain (Ordiz et al. 2022), Wolves in Spain were classified as a game species north of the Douro River but recent national listing has resulted in a discontinuation of recreational harvests (Ordiz et al. 2022). Previous harvests found the average annual limit was 19% of the population (Blanco et al. 1992). At this level of legal take, plus poaching, the population reportedly continued to expand into new areas and was considered stable or increasing in 2000 (Boitani 2003).

Until recently, wolves in Poland were classified as a game species. With an estimated population of 900 wolves, the annual bag limit was approximately 110 wolves, or 12% of the population (Bobeck et al. 1993). With this level of take, the population continued to expand. Today, wolves in Poland are officially protected with an estimated population of about 3,000 individuals.

The Russian wolf population does not receive any legal protection and was estimated to include approximately 25,000–30,000 animals. Despite the complete lack of regulation, the population was considered to be stable or increasing in 2000 (Boitani 2003). Indeed, more recent estimates since the year 2000 suggest the wolf population has ranged from about 45,000-55,000 individuals (Baskin 2016). Annual reported wolf harvests ranging from about 5,000 to 12,000 individuals, with long-term patterns in harvest associated with famine and social turbulence (Baskin 2016). Similar to the situation in Alaska, limited road access and winter conditions also likely prevents higher levels of annual harvest.

Relevance to Michigan

Harvests currently occurring elsewhere in North America seem most relevant when considering a public take in Michigan. However, comparisons between wolf harvests in Alaska and Canada and a potential harvest in Michigan are problematic. Most areas in Alaska and Canada have fewer roads, less access, and far fewer hunters and trappers interested in harvesting wolves. Because of better access and other conditions, hunter and trapper success rates in Michigan could be higher than in these areas. However, many areas of Alaska and western Canada consist of vast open expanses, which make wolves vulnerable to hunters. In Michigan, most wolf habitat consists of dense forests, which provide defense against shooting and could help wolves elude hunters. Therefore, success rate of wolf hunting in Michigan compared to that in Alaska and Canada is difficult to predict. In general, trapping appears to have a higher success rate than hunting.

The legal status of wolves in the Great Lakes region at the Federal level has changed multiple times since March 2007, when wolves were removed from the Federal List of Threatened and Endangered Species, only to be placed back on the list in September 2008. A second attempt to delist wolves became effective in May 2009, however wolves were formally returned to the List by September 2009. In January 2012, wolves were once again federally delisted which lasted until December 2014 when a federal court vacated the U.S. Fish and Wildlife Service's delisting. The latest attempt to federally delist wolves became effective in January 2021, but this attempted was also vacated by a U.S. District judge returning wolves to the Endangered Species List in February 2022.

In Michigan, wolves were removed from the State Threatened and Endangered Species List (Part 365 of Public Act 451 of 1994) in April 2009 and given Protected Animal status under the State's Wildlife Conservation Order. In the fall of 2013, when wolves were federally delisted, Michigan held its first public harvest of wolves as a management tool to resolve chronic negative wolf-human interactions. The laws which reclassified wolves as a game species in Michigan were repealed by voter referendum in November 2014. However, in August 2014 prior to the public vote, citizen-initiated legislation (Public Act 281) classified wolves as game animals. Public Act 281 added the authority to classify species as game animals to the NRC's already existing authority to decide if a game species will be hunted, and the parameters around a regulated harvest. An organization (Keep Michigan Wolves Protected) challenged the constitutionality of Public Act 281 however the Michigan Court of Claims dismissed the lawsuit in July 2015. Then in November 2016, an appellate court overturned the 2015 Michigan Court of Claims ruling removing the NRC's authority to classify gray wolves as a game species. Nine days after the appellate court ruling a Senate Bill was introduced which once again granted authority to the NRC reclassify wolves in Michigan as a game species when it was signed into law in December 2016 (Public Act 382).

Wolves are currently listed as game animal in Michigan however, they were once again placed back on the Federal Endangered Species List on February 10, 2022. If wolves are federally delisted the Michigan DNR believes that before a wolf hunt should be considered, several things should take place: 1.) The legal status of wolves should be more permanently settled, especially given the long history of legal challenges to delisting decisions and the resulting shifting status of wolves, 2.) The DNR's wolf management plan should be updated upon completion of a public attitude study in 2022, and 3.) The DNR should consult with the federally recognized tribal governments located in Michigan prior to developing any potential hunt.

Wolf Population Control Programs

In addition to legal harvest, wolf control programs have been carried out by government agencies in Alaska and Canada to reduce wolf numbers in specific areas. The primary purpose of these control programs has been to allow populations of game species such as moose and caribou to increase. Larger populations of ungulates were desired for increased harvest by recreational and/or subsistence hunters (National Research Council 1997). Most, if not all, of these control programs were controversial.

The National Research Council (1997) conducted an extensive review of ten predator-control projects designed to increase the number of ungulates available for human harvest. Eight of these projects involved a reduction of wolves using aircraft and two involved ground-based wolf control. The National Research Council (1997) concluded that problems in how these predator-control experiments were conducted limited how much could be learned from these efforts. Nevertheless, the Council found that "wolf control . . . resulted in prey increases only when wolves were seriously reduced over a large area for at least four years." It cautioned that the experiments that appeared to be successful used methods (e.g., aerial shooting) that were not politically acceptable. It is not known from these studies whether wolf numbers can be reduced sufficiently with less-controversial methods. Further, the Council found that wolf populations usually recovered to pre-control levels within 4 or 5 years after control efforts had stopped. The design of these experiments did not allow investigators to determine whether the control programs resulted in higher ungulate numbers that lasted long after predator control was stopped.

In Alaska, Valkenburg et al. (2004) investigated the effects of wolf control on caribou calf survival in the Delta herd and found that wolf control did not increase caribou calf survival. Though the fall 1993 wolf population in this area was reduced 60-62%, summer 1995-1997 wolf-caused calf mortality was 25%.

Probable factors contributing to this failure included predation of calves by other predator species and too few wolves removed to be effective (Valkenburg et al. 2004).

Only one study has examined wolf control in an area where white-tailed deer (*Odocoileus virginianus*) are the primary prey. Potvin et al. (1992) evaluated the effect of reducing wolves in a reserve in Quebec on deer numbers, fawn survival and buck harvest. Similar to other wolf-control programs, wolf removal was conducted by aerial shooting. Because of heavy forest cover, wolves were captured and radio-collared during the summer to aid in locating packs during the winter control operations. The results of this study were at least partially confounded by a series of mild winters that allowed deer numbers to increase in the area where no wolf control was applied. Despite this problem, in the area where wolf numbers were reduced by an average of 71% for 3 years, the deer population increased at a rate 15% higher than in the area where no wolf control was applied. This increase in deer numbers did not result in a measurable increase in buck harvest.

Poison

In the past, baits containing poison were often used to eliminate wolves and coyotes from areas in North America and Europe (Sillero-Zubiri and Switzer 2004). Poison baits can be effective, inexpensive to use, but they can kill non-target species (e.g., bears, dogs) and are poorly regarded by the public (e.g., Proulx et al. 2015). Poison (strychnine and compound 1080) used for predator management was banned in the United States in 1972 (Fritts et al. 2003). Strychnine has been used in Alberta to reduce wolf abundance to reduce predation of endangered caribou (Hervieux et al. 2014); 225 wolves were killed from 2005-2018. The wolf population control program appeared to stabilize the caribou population but did not result in an increase (Hervieux et al. 2014).

Bounties

Bounties are rewards, usually money, given as an incentive for people to capture and/or kill an animal considered to be a threat or pest. In contrast to other wolf population management strategies, bounties are unique because their aim is not to reduce wolf numbers or maintain them within specified limits, but rather to facilitate population reduction or extirpation of a species from a particular area (Boitani 2003). Bounties for the killing of wolves have a long history (Boitani 2003), beginning in Greece in the sixth century B.C. In medieval Europe, efforts to exterminate wolves became organized and focused on killing as many animals as possible, a strategy that continued until the late 1800s (Mallinson 1978). In France, for example, two laws enacted between 800 and 813 A.D. entitled special wolf hunters to receive payment from residents within 4 miles of a kill site (Hainard 1961, Victor and Lariviere 1980). In 1883, 1,386 wolves were killed via this program (Victor and Lariviere 1980).

In the area of the lower 48 United States, bounties on wolves were instituted by English colonists in Plymouth, Massachusetts in 1630 (Boitani 2003), approximately 120 years after the last wolves in England were killed (Beddard 1909). By 1700, wolves were exterminated from New England. As the country expanded with settlement westward, principal wolf prey species such as bison (*Bison bison*) were killed off to facilitate livestock grazing (Fritts et al. 2003). Lacking their normal prey, wolves increasingly killed domestic stock. This behavior fueled wolf-extermination efforts, often through use of bounties. In Montana, for example, bounty legislation was enacted in 1883, and by 1930, wolves had been eradicated from that State (Riley et al. 2004). Compared to the rest of the country, wolf populations in the Upper Great Lakes region persisted longer. Bounties were repealed in Wisconsin in

1957, in Michigan in 1960, and in Minnesota in 1965 (Thiel 1993). However, by 1970, the wolf population in the Upper Great Lakes region was restricted to northern Minnesota, and individual wolves were observed only occasionally in Wisconsin and Michigan.

These historical accounts suggest bounties can be extremely effective in managing wolf populations if the management objective is extermination. This effectiveness is enhanced in situations where the population is small and accessible, and mitigated, at least to some extent, when the population is in a remote area (as in Minnesota). The critical threshold occurs when bounty-driven killing exceeds the reproductive rate of the population. Historically, bounty killing was somewhat more effective when carried out by government-sponsored professionals than the general public, but both approaches eventually exterminated the targeted wolf populations.

Though wolf bounties are currently rare in North America, five U.S. states had wolf bounties until as late as 1971 (Cain et al. 1972) and bounty programs in western Canada ended during the 1950s to early 1970s (Proulx and Rodtka 2015). More recently, Alberta and Saskatchewan reinstated bounties for wolves and other carnivores in 2007 and 2009, respectively, to reduce livestock depredations and increase ungulate abundance for hunting (Proulx and Rodtka 2015). In 2021, the State of Idaho offered compensation for wolves taken during recreational harvests in areas with high livestock depredations.

Michigan had a bounty on wolves until 1922 when a state-paid trapper system was initiated with a similar intent of extirpating wolves (Beyer et al. 2009). The trapper system was implemented through the United States Bureau of Biological Surveys and supported by funds derived from the sale of deer hunting licenses (Beyer et al. 2009). The state trapper program continued until 1934 and during this latter program, 855 wolves, or an average of 66 wolves each year, were killed (Beyer et al. 2009).

The economics of bounties are complex. Economic losses from depredation of livestock have historically been one of the most common arguments use to justify bounties (Fritts et al. 2003). However, the costs of administering bounty programs can be substantial. By one estimate, over 300 years of North American wolf bounty programs cost governments, livestock associations and private individuals approximately $100 million (Hampton 1997). During the Soviet period, Russia spent more than $300 million on wolf bounties and other payments related to wolf damage (Fritts et al. 2003). Whatever the actual costs, the necessity of making bounty payments and administering a bounty program are always financial liabilities to a government agency.

Zoning

The development and use of zones to manage wildlife is a common approach applied by many natural-resource organizations. Zones can be developed and applied for a number of reasons, including controlling species distribution, varying population density across the landscape, and regulating harvest (e.g., harvest levels, season length, season timing, bag limits). Zoning has been applied in wolf recovery plans (U.S. Fish and Wildlife Service 1992, 2020) as well as State management plans that will be implemented after the wolf is removed from the Federal List of threatened and endangered species (Wisconsin DNR 1999, Minnesota DNR 2001). Zone management for wolves is designed to vary management according to available wolf habitat and the potential for wolf–human conflict (Wisconsin DNR 1999). In Minnesota and Wisconsin, wolf-management zones have been developed primarily to manage wolf depredation of livestock. Wyoming's proposed wolf management plan included the use of zones to differentiate management in National Parks and Forest Service wilderness areas and the remainder of the State (Wyoming Game and Fish Department 2003). The Idaho and Montana wolf management plans do not incorporate zoning but Montana does vary management based on patterns of land ownership (Idaho Legislative Wolf Oversight Committee 2002, Montana Fish, Wildlife and Parks 2003).

Passive Management

Another approach to management of wolf population size and distribution would be to not actively manage the population and let it naturally regulate itself. Under such an approach, wolf populations would be allowed to increase to the maximum number the habitat could support. As populations approached biological limits, natural checks on wolf numbers, such as starvation and disease, would likely increase. Large die-offs due to disease during periods of stress, such as winter, would be possible. No effort would be expended to control population size. However, this approach would probably require more agency resources for managing wolf–human conflicts.

The number of wolves which could occur in the Upper Peninsula (UP) in the absence of human-induced population control can only be roughly estimated. Potvin et al. (2005) developed a spatial habitat model of suitable wolf habitat. Results from the model suggest approximately 27,700 km^2 of habitat in the UP could be occupied by wolves. Maximum midwinter wolf densities (excluding Isle Royale) usually do not exceed 40 wolves per 1,000 km^2 (Fuller et al. 2003). Applying this wolf density to the estimate of suitable wolf habitat suggests the UP could support approximately 1,100 wolves. Similarly, Potvin (2003) estimated the carrying capacity of the Upper Peninsula ranged from 590 to 1,330 wolves. An alternative estimate of carrying capacity was 1,300 wolves in Wisconsin and Upper Peninsula of Michigan combined (Van Deelen 2009), a number exceeded years previous.

Attitudes of Michigan Residents

Setting goals for wolf abundance and distribution in Michigan will be challenging given the conflicting preferences and tolerances of stakeholders. Another challenge will be to determine how to achieve those goals once they are established. Understanding public attitudes regarding the management options is a fundamental step in that process.

This section discusses relevant findings from the 2021 public-attitude study (Riley et al. 2022) which surveyed a sample of more than 15,000 Michigan residents. Details of the study methods and additional results are presented elsewhere in this document (i.e., Chapter 2).

In general, patterns of support for management of wolf numbers and distribution were closely tied to the method being proposed. Respondents were asked if one or more wolves had to be removed from an area for some reason, how acceptable would a variety of methods be. Some of the methods reflect passive interventions and some reflect active methods. In the weighted sample of the general public, use of licensed hunters to remove wolves received the greatest support and use of trained, paid professionals received the least support (see Figure 3-1). These patterns hold across regions. This is consistent with the results of the 2005 survey of Michigan residents.

- The use of trained, paid professionals to shoot wolves was supported (deemed highly or moderately acceptable) by 29.8% and opposed (deemed highly or moderately unacceptable) by 31.3% of interested respondents statewide. Support was greatest in the UP (34.9%) and least in NLP (27.9%).

- The use of trained, paid professionals to trap and lethally remove wolves was supported (deemed highly or moderately acceptable) by 22.1% and opposed (deemed highly or moderately unacceptable) by 44.6% of interested respondents statewide. Support was greatest in the UP (31%) and least in NLP (20.7%).
- Providing a limited number of permits to licensed hunters to shoot wolves during a controlled hunting season was supported (deemed highly or moderately acceptable) by 48.5% and opposed (deemed highly or moderately unacceptable) by 20.4% of interested respondents statewide. Support was greatest in the UP (63.6%) and least in SLP (43.5%).
- Providing a limited number of permits to licensed fur trappers to remove wolves was supported (deemed highly or moderately acceptable) by 43% and opposed (deemed highly or moderately unacceptable) by 30.7% of interested respondents statewide. Support was greatest in the UP (57.8%) and least in SLP (38.8%).

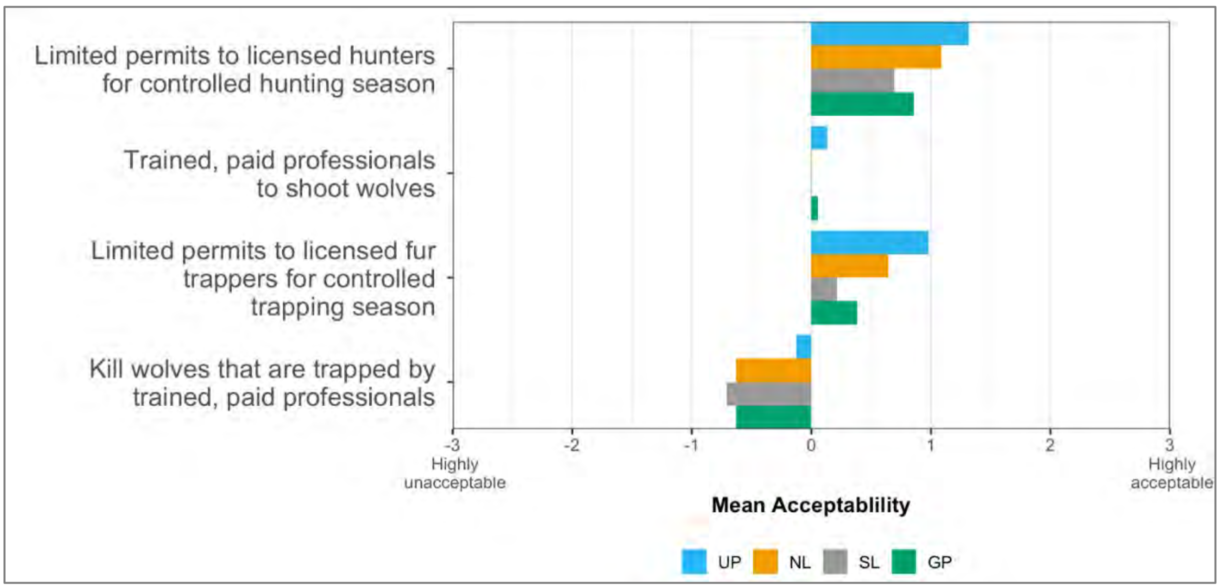

Figure 3-1 If a wolf or wolves had to be removed from an area for some reason, how acceptable are the following possible methods to you personally?

The lower approval of wolf trapping is consistent with the lower approval of trapping generally reported among the general public. This is consistent with past Michigan research. For example, Koval and Mertig (2002) reported findings of three Michigan surveys (in 1999, 2000 and 2001) showing three-fourths of the public were not opposed to recreational hunting, but only half accepted trapping for fur.

Because hunters may hold different opinions regarding some of the four options than the general public, a summary of hunter responses are reported below.

- The use of trained, paid professionals to shoot wolves was supported (deemed highly or moderately acceptable) by 28% and opposed (deemed highly or moderately unacceptable) by 30%.

- The use of trained, paid professionals to trap and lethally remove wolves was supported (deemed highly or moderately acceptable) by 28% and opposed (deemed highly or moderately unacceptable) by 33.6%.
- Providing a limited number of permits to licensed hunters to shoot wolves during a controlled hunting season was supported (deemed highly or moderately acceptable) by 76.9% and opposed (deemed highly or moderately unacceptable) by 5.8%.
- Providing a limited number of permits to licensed fur trappers to remove wolves was supported (deemed highly or moderately acceptable) by 68.8% and opposed (deemed highly or moderately unacceptable) by 9%.

Chapter 4 Wolves and Human Safety

Executive Summary

Worldwide, most wolf attacks on humans in the past century have involved rabid wolves, habituated wolves, provocation by humans, or highly modified environments. Between 1900 and 2002, confirmed wolf attacks in North America caused two human deaths. From 2002 to 2020, six people were injured and two people died from wolf attacks in North America.

Most wildlife has the potential to be dangerous to humans in certain situations. In most cases, people can take simple, sensible measures to avoid those situations and protect themselves against harm. Other cases may warrant higher levels of concern and professional assistance. Accurate perceptions of the human-safety risks posed by wildlife can facilitate appropriate levels of concern and responses to particular situations.

Segments of the public can overestimate or underestimate the actual human-safety risks posed by wolves. Some people may feel the mere presence of a wolf population poses a serious safety threat, whereas others may not recognize that wolves could be dangerous to people in certain situations. However, direct threats to humans are extremely rare.

Most Michigan residents place a high priority on wolf management that addresses public concerns for human safety. The Michigan DNR strives to minimize conflicts between wolves and people. The DNR in conjunction with USDA Wildlife Services provides technical assistance and educational material to landowners to avoid unnecessary wolf problems and to maintain public support for sound scientific wolf management.

Public-safety risks and concerns posed by wolves can be reduced through several management approaches. Reducing the incidence of rabies and providing ample natural prey are important ways to help prevent wolf attacks. Public education on the use of techniques to help prevent the habituation of wolves can help reduce risks to public safety. Public education could also help foster a realistic understanding of the risks and impacts of Michigan wolves. In the past, problem wolves in Michigan were captured and released in remote areas on public lands. However, due to several problems associated with this technique, relocation is no longer a recommended option. Aversive conditioning, which may include the use of rubber bullets, cracker shells, or electronic dog-training collars (shock collars), is another tool to help prevent habituation of wolves near human residences.

Lethal control is another option to reduce threats to human safety posed by wolves. Under Federal regulations, Michigan Department of Natural Resources employees and designated agents can take endangered wildlife, without a permit, to remove animals that constitute a demonstrable but non-immediate threat to human safety. Federal regulations also state that any person may take endangered wildlife in defense of human life. Results of the 2021 public-attitude survey (Riley et al. 2022) indicate the risk to human safety posed by wolves is an important concern among Michigan residents. Respondents were asked to think about where wolves exist in Michigan (exclusively in the UP) and assess how much risk those wolves pose. Approximately half of survey respondents indicated that wolves pose some risk to themselves or other people, with approximately 25% indicating wolves pose a moderate or large amount of risk. However, there were some differences by region, with UP residents more likely to indicate they perceived a moderate or large amount of risk to themselves or others

(39.6%) compared to residents in the NLP (27.4%) and SLP (21.1%). It is important to note that perceptions of risk reflect subjective and not objective assessments of risk; actual risk to human health and safety are low (Ghasemi et al. 2021; Vaske et al. 2021).

Respondents to the public-attitude survey were asked to express their support or opposition to several management options when applied to different scenarios of wolf issues: (1) a wolf seen in residential areas; (2) a wolf killing someone's pet; (3) a wolf killing a free-ranging hunting dog; (4) a wolf killing livestock; and (5) a wolf attacking a human. The management options offered were to: do nothing, monitor the situation, frighten the wolf, capture and move the wolf, kill the wolf, reduce the size of the population; and in the livestock depredation scenario, use tax dollars to compensate the producers. The only interaction that elicited acceptability by the majority of respondents for killing wolves was attacks on humans. Passive management, or a "do nothing" alternative, was the least acceptable action for every situation.

Introduction

In a recent study of wolf attacks worldwide, Linnell et al. (2002, 2021) identified five factors commonly associated with wolf attacks on humans:

- rabies
- habituation
- provocation
- highly modified environments (e.g., agriculture, parks)
- predatory behavior

Numerous records of attacks were made prior to the 20th century, but many cannot be verified. From 1900 to 2002, 273 attacks causing a total of 27 human deaths have been documented in Europe; more than 80% of those attacks involved rabid wolves. Attacks have been more frequent in India, Russia, China, Iran and Afghanistan, where 1,579 attacks were reported through 2003; more than 70% of them involved rabid wolves (Linnell et al. 2002, U.S. National Park Service 2003a). Predatory attacks on children are more frequent in countries such as India and Iran (Linnell et al. 2021). Because of major differences in ecology, geography and local conditions, the frequency of attacks in other areas of the world may not accurately indicate the risks to humans posed by wolves in North America.

Wolf attacks in North America since 1900 were summarized by McNay (2002a,b). Eighty wolf–human encounters were reviewed and classified based on seven types of wolf behaviors considered to be causative factors in the attack. Behavior types included agonism (aggressive behavior), predation, prey testing (assessment of an individual as a potential prey item), self-defense, rabies, investigative searches, and investigative approaches. Thirty-nine cases involved aggression by apparently healthy wolves, 12 cases involved rabid wolves, and 29 cases involved fearless or habituated wolves. Included in these cases were several attacks on children, primarily in Alaska and Algonquin Park, Ontario, which resulted in severe injuries in some cases. Between 1900 and 2002, wolf attacks in North America resulted in only two confirmed deaths, both involving rabid wolves (McNay 2002a,b). Linnell et al. (2021) summarized additional wolf attacks in North America. During this period two people died (one each from the US and Canada) and seven people were injured (two from the US and five from Canada (Linnell et al. 2021). The two human fatalities and four of the seven human injuries were attributed to predatory wolf behavior (Linnell et al. 2021).

Management Options

Linnell et al. (2021) listed four options of increasing invasiveness (and from proactive to reactive) available to respond to wolves that demonstrate unwanted behavior:

- remove food sources
- hazing
- selective animal removal
- wolf hunting

Linnell et al. (2021) also identified the need to have clear management guidelines in place that identify how to respond in various situations.

Table 4-1 Wolf behavior and associated risk assessment for human safety with recommendations for action (from Linnell et al. 2021).

Behavior	Assessment	Recommendation for action
Wolf passes close to settlements in the dark.	Not dangerous.	No need for action.
Wolf moves within sighting distance of settlements / scattered houses during daylight.	Not dangerous.	No need for action.
Wolf does not run away immediately when seeing vehicles or humans. Stops and observes.	Not dangerous.	No need for action.
Wolf is seen over several days <30m from inhabited houses (multiple events over a longer time period).	Demands attention. Possible problem of strong habituation or positive conditioning.	Analyze situation. Search for attractants and re-move them if found. Consider aversive conditioning.
Wolf repeatedly allows people to approach it within 30m.	Demands attention. Indicates strong habituation. Possible problem of positive conditioning.	Analyze situation. Consider aversive conditioning.
Wolf repeatedly approaches people by itself closer than 30m. Seems to be interested in people.	Demands attention / critical situation. Positive conditioning and strong habituation may lead to an increasingly bold behavior. Risk of injury.	Consider aversive conditioning. Remove the wolf if appropriate aversive conditioning is not successful or practical.
Wolf attacks or injures a human without being provoked.	Dangerous.	Removal.

In North America, strategies to prevent wolf habituation through aversive condition have more recently received attention. For example, at least two national parks have established wolf–human conflict management plans (U.S. National Park Service 2003, 2007) that address management of fearless or habituated wolves. These plans focus on a graduated series of responses (e.g., U.S. National Park Service 2007). Categories of responses in order of their use include:

1) public education and prevention measures
2) aversive conditioning of fearless wolves
3) temporary closures of facilities with fearless wolf problems
4) translocation or lethal removal

Michigan has developed a similar approach based on the severity, immediacy and frequency of safety threats, which is detailed in the Michigan Nuisance Wolf Management Guidelines (Michigan Department of Natural Resources 2022a). More-conservative management methods will be applied when the risk of physical harm to humans is considered to be relatively small and non-immediate, whereas increasingly aggressive methods may be applied as the severity, immediacy or frequency of threats increase.

Vehicle Collisions

There is limited information on the potential effects of wolves in reducing the number of white-tailed deer-vehicle collisions. Raynor et al. (2021) suggested that wolves could reduce deer-vehicle collisions by 24% in Wisconsin counties within wolf range. These authors suggested deer use of roadways was reduced due to fear of wolves that used these roadways. However, their study was correlational and several alternative explanations regarding types of roads wolves used and where deer-vehicle collisions occurred (e.g., primary vs. secondary) as well as variation in traffic volumes were not considered. Further, more than 40% of data points used were for counties in years where wolf densities were less than one wolf per 100 mi^2, and more than 60% were less than two wolves per 100 mi^2. It seems implausible that wolf densities this low would alter deer behavior of this magnitude.

Public Education and Prevention

Several techniques appear to be somewhat effective at reducing the impacts and risks of fearless and/or nuisance wolves. Public education on the use of those techniques may help prevent the habituation of wolves and help reduce risks to public safety. Public education may also help foster a realistic understanding of the risks and impacts of Michigan wolves.

In 2004, the Michigan DNR began distributing a wolf-activity report form designed to track (1) citizens' concerns or complaints about wolf activity in their areas and (2) agency responses to those issues (Prior to 2004, only depredation complaints and wolf observations were recorded). The number of wolf-activity reports peaked in 2012 but have since continued to see a general decline each year. In 2001, DNR developed an online reporting system for citizens to report observations of wolves. This online reporting system is designed to capture sightings only, not animals which are considered by the public to be causing a nuisance situation. This online system has also proven to be a valuable tool for identifying potential wolves in the NLP.

In response to concerns or complaints about wolf activity, Michigan DNR and USDA Wildlife Services personnel frequently make site visits to determine the cause of the concerns and to discuss options for minimizing the perceived problems. When livestock are involved at particular sites, agency personnel use site visits to discuss husbandry practices that could minimize or eliminate wolf problems, even though neither the Michigan DNR, nor USDA Wildlife Services, has the authority to enforce livestock practices that may reduce wolf–livestock conflicts.

Relocation/translocation

In the past, problem wolves in Michigan were captured and released in remote areas on public lands. However, relocation is no longer recommended as a management technique. Unoccupied wolf territories for relocated animals are no longer available, and because research has shown translocated wolves do not remain near release sites (Michigan DNR, unpublished data). Moreover, residents have expressed opposition to the release of wolves near their communities.

Aversive Conditioning

An aversive stimulus causes discomfort, pain, or an otherwise negative experience. Examples of aversive stimuli previously used on wolves include rubber bullets, cracker shells, and electronic dog-training collars (shock collars) (Rossler et al. 2012, Meadows and Knowlton 2000, Koehler et al. 1990). Effectiveness of aversive conditioning is dependent on learning; wolves may not associate aversive stimuli with their problematic behavior.

In Michigan, a wolf behavior modification kit (a device capable of firing loud cracker shells) is available to residents as a means to conduct aversive conditioning. The personal ability to actively manage wolves with such a device has met with approval among private individuals (B. Roell, Michigan DNR, personal communication). Other items that have been used on occasion in Michigan have been propane cannons, siren/light scare devices, and flashing construction lights.

Lethal Control

Killing habituated or nuisance wolves is generally tolerated by the public, but it is regularly scrutinized if non-lethal techniques are available (Fritts et al. 2003). Results of the 2005 and 2021 public-attitude surveys indicate public support for killing wolves contingent on the type of risk that they pose. Support for lethal control is greatest if wolves should threaten human health and safety. There are some apparent regional differences with people in the UP who are more accepting of lethal control under all circumstances except when a wolf kills a hunting dog. Lethal control is not acceptable to the majority of interested people unless the risks directly involve human health and safety. Support for reduction of the wolf population is correlated to the pattern of support for lethal control of individual wolves. A comparison of the 2002 (Mertig 2004) and 2005 surveys with the 1990 survey (Kellert 1990) suggests support for lethal control may be increasing with recognition that wolf populations have increased.

Lethal-control methods could be implemented either by government agents, licensed hunters, licensed fur harvesters, or by livestock growers. Current research in Michigan suggests, however, that preference is greater for licensed hunters or fur harvesters than government agents. Chapter 5 on depredation of domestic animals provides a more-detailed discussion of attitudes regarding this and other management options. Public Act 451 1994 allows citizens to kill a wolf in defense of human life regardless of protection afforded wolves in Michigan.

In Michigan, 32 wolves have been killed for human safety concerns since 2004. Michigan DNR staff or USDA-WS personnel killed 31 of the 32 wolves. A private citizen killed a single animal in 2019 in Luce County.

Legal Considerations

Under Federal regulations (50 CFR 17.21(c)(3)), Michigan DNR employees and designated agents can take endangered wildlife, without a permit, to remove animals that constitute a demonstrable but non-immediate threat to human safety, provided the taking is done in a humane manner. The taking may involve killing or injuring only if it has not been reasonably possible to eliminate such threat by live-capturing and releasing the specimen unharmed in a remote area. In addition, the U.S. Endangered Species Act's implementing regulations (50 CFR 17.21(c)(2)) allow take of listed species by any person to safeguard human safety provided specific reporting conditions are met.

In the fall of 2008, two bills (House Bill No. 5686 and Senate Bill No. 1084) were signed into law, which became Public Act 290 and 318 respectively. These two Public Acts allow citizens to use lethal control on wolves that are in the act of killing or wounding livestock or a dog when wolves are not federally protected. When wolves are not federally protected, they are still a protected game species and the taking of a wolf that is not in the act of killing or wounding livestock or a dog is illegal.

Attitudes of Michigan Residents

Public-attitude Surveys: 1980s–2021

In the 1980s, national studies documented contemporary American attitudes toward wolves (Kellert 1985, 1986). These studies indicated the percentage of Americans with negative views of wolves was almost as large as that which held positive views. Livestock producers as a group were conspicuous in their strong negative views of wolves. Llewellyn (1978) reviewed and analyzed letters to the U.S. Fish and Wildlife Service concerning downlisting of wolves in Minnesota and found wide variations in attitudes toward wolves. In general, the most favorable impressions of wolves were held by wildlife advocates and residents of urban areas, whereas the most unfavorable positions were held by people in rural areas living closest to Minnesota's wolf range.

Kellert (1990) conducted a survey of public attitudes and beliefs about wolves in Michigan. He found strong support for wolves among most stakeholder groups, with the notable exception of farmers. Deer hunters and trappers had strong positive opinions of wolves. In general, Lower Peninsula (LP) residents were supportive of wolves but exhibited more fear and less knowledge of wolves than did Upper Peninsula (UP) residents. Kellert's survey was conducted in 1990, when wolves were just beginning to re-occupy the UP.

A follow-up survey was conducted by the Michigan State University Department of Sociology in 2002 (Mertig 2004). By this time, wolves had become well established in the UP. The results of the survey indicated there had been a decline in fear of wolves since the previous survey. Although the public was still generally supportive of wolves, the survey also found strong support for managing both nuisance wolves and wolf numbers. Concerning fear of wolves, 21% of respondents strongly or moderately agreed with the statement: 'wolves in the woods are dangerous to people.' Twenty-nine percent agreed with the statement: 'if I were in the woods and saw a wolf, I would be afraid it might attack me.' Responses to questions concerning management of nuisance wolves indicated considerable support for ‘leaving wolves alone so long as no one is injured’ (84% of respondents strongly or moderately agreed with this statement). Seventy-three percent of respondents strongly or moderately agreed with ‘kill[ing] individual wolves definitely known to be causing problems for people.’ Eighty-four percent of respondents agreed with ‘trap[ping] and relocate[ing] individual nuisance wolves.’ Support for ‘killing wolves to reduce their numbers’ was mixed: 39% of respondents strongly or moderately supported this action, whereas 35% of respondents strongly or moderately opposed it.

Results of the 2005 public-attitude survey did not suggest a continuation of the decline in public fear of wolves found by Mertig’s 2002 survey. The 2005 data suggested a substantial portion of the public in northern areas consider the public-safety threat posed by wolves to be a serious factor when considering wolf-population goals. The importance of public-safety concerns was assessed by asking whether respondents agreed with the statement: ‘the chance of a wild Michigan gray wolf hurting or killing a human is great enough that it should be an important factor in deciding how many wolves are allowed to live in Michigan.’ Approximately half of the respondents statewide agreed with the statement and one-third disagreed. Agreement was strongest in the UP and the Northern LP (56% and 55% agreed, respectively) and lowest in the two urban samples (38% of the Southern LP metro and Detroit samples agreed). Approximately 16% of respondents in each region strongly disagreed.

Results of the 2021 public-attitude survey indicate the risk to human safety posed by wolves continues to be an important concern among Michigan residents. Respondents were asked to think about where wolves exist in Michigan (exclusively in the UP) and assess how much risk those wolves pose. Approximately half of survey respondents indicated that wolves pose some risk to themselves or other people, with approximately 25% indicating wolves pose a moderate or large amount of risk. However, there were some differences by region, with UP residents more likely to indicate they perceived a moderate or large amount of risk to themselves or others (39.6%) compared to residents in the NLP (27.4%) and SLP (21.1%). Please see the tables below for more information.

Risk Perceptions

Thinking about where wolves exist in Michigan (exclusively in the Upper Peninsula), please indicate how much risk you personally believe wolves pose.

Pets, such as dogs around the house.

Response	**UP Population**	**NLP Population**	**SLP Population**	**Total Population**
No Risk at All	7.2%	8.7%	11.4%	9.5%
Some Risk	30.6%	39.2%	38.6%	37.6%
A Moderate Amount of Risk	28.8%	29.6%	35.8%	33.9%
A Large Amount of Risk	33.4%	22.5%	14.1%	18.9%

Hunting dogs such as those out hunting or training.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	4.4%	6.6%	7.9%	7.4%
Some Risk	23.5%	35.3%	41.5%	37.7%
A Moderate Amount of Risk	28.8%	33.9%	32.3%	33.4%
A Large Amount of Risk	43.3%	24.2%	18.3%	21.4%

Livestock such as cattle, sheep, goats, or chickens.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	0.9%	1.8%	2.8%	2.0%
Some Risk	17.7%	24.2%	21.8%	21.9%
A Moderate Amount of Risk	27.7%	35.5%	38.9%	37.2%
A Large Amount of Risk	53.7%	38.5%	36.5%	38.9%

Personal property other than animals.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	53.1%	48.2%	50.8%	50.7%
Some Risk	27.3%	34.1%	35.6%	34.3%
A Moderate Amount of Risk	11.8%	13.0%	11.1%	11.2%
A Large Amount of Risk	7.7%	4.8%	2.5%	3.8%

Personal safety of myself or other people.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	21.2%	24.3%	21.2%	22.0%
Some Risk	39.2%	48.3%	57.7%	53.5%
A Moderate Amount of Risk	23.4%	19.1%	15.7%	17.3%
A Large Amount of Risk	16.2%	8.3%	5.4%	7.3%

Personal safety of children specifically.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	13.8%	13.7%	12.0%	12.4%
Some Risk	33.4%	45.8%	48.2%	45.2%
A Moderate Amount of Risk	23.8%	24.2%	24.8%	24.0%
A Large Amount of Risk	29.1%	16.4%	15.0%	18.4%

Populations of white-tailed deer.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	6.3%	8.4%	15.4%	12.6%
Some Risk	10.2%	23.1%	22.7%	20.6%
A Moderate Amount of Risk	24.5%	35.2%	35.2%	34.2%
A Large Amount of Risk	59.0%	33.3%	26.7%	32.7%

Populations of moose.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	8.5%	12.6%	16.5%	14.1%
Some Risk	20.8%	35.1%	39.0%	36.2%
A Moderate Amount of Risk	32.5%	29.5%	25.5%	26.8%
A Large Amount of Risk	38.2%	22.8%	19.0%	22.9%

The natural balance of Michigan's ecosystems.

Response	UP Population	NLP Population	SLP Population	Total Population
No Risk at All	30.2%	39.8%	43.9%	42.1%
Some Risk	24.4%	29.5%	29.4%	27.2%
A Moderate Amount of Risk	21.2%	18.3%	18.1%	19.3%
A Large Amount of Risk	24.2%	12.4%	8.6%	11.5%

Respondents to the 2021 public-attitude survey were also asked to express their support or opposition to several management options when applied to different scenarios of wolf issues: (1) a wolve seen in residential areas; (2) a wolf killing someone’s pet; (3) a wolf killing a free-ranging hunting dog; (4) a wolf killing livestock; and (5) a wolf attacking a human. The management options offered were to: do nothing; monitor the situation, frighten the wolf, capture and move the wolf, kill the wolf, reduce the size of the population; and in the livestock depredation scenario, use tax dollars to compensate the producers. The only interaction that elicited acceptability by the majority of respondents for killing wolves was attacks on humans. Passive management, or a “do nothing” alternative was the least acceptable action for every situation. Responses to these scenarios are presented in the following figures 4.1, 4.2, 4.3, 4.4, 4.5, 4.6.

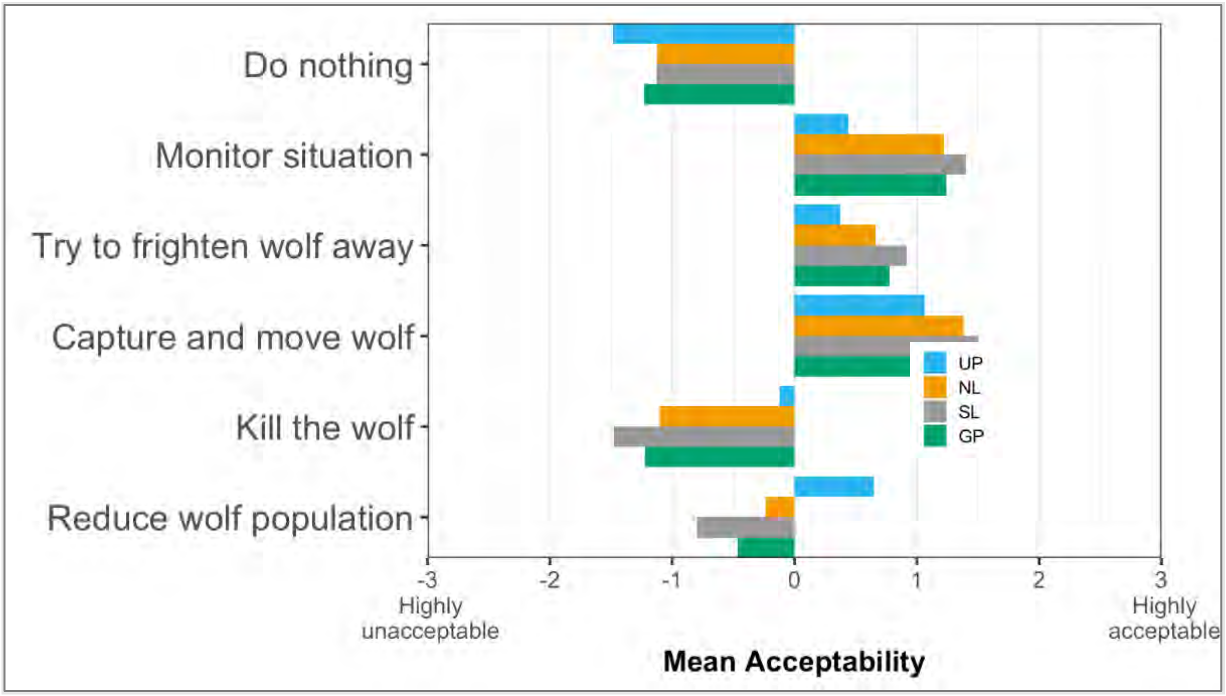

Figure 4-1 If a wolf (wolves) is seen in residential areas, how acceptable is it for the MI DNR to take each of the following actions?

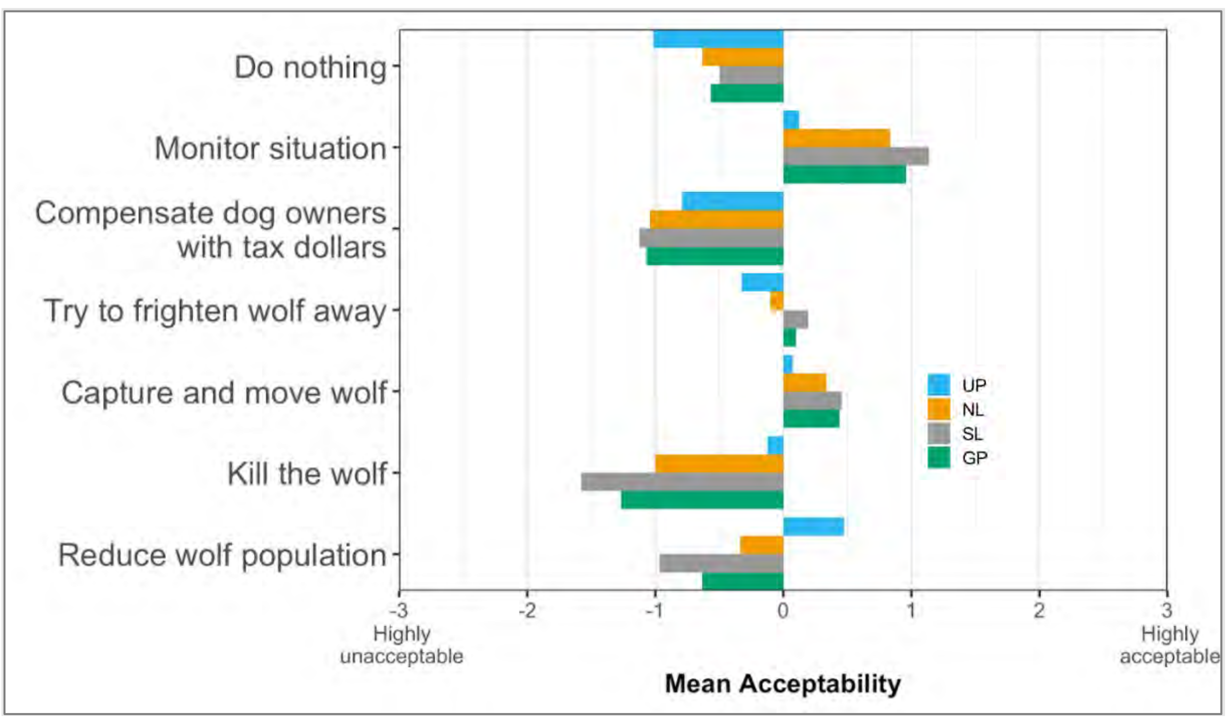

Figure 4-2 . If a wolf (wolves) kills a free-ranging hunting dog while out hunting or training, how acceptable is it for the Michigan DNR to take each of the following actions?

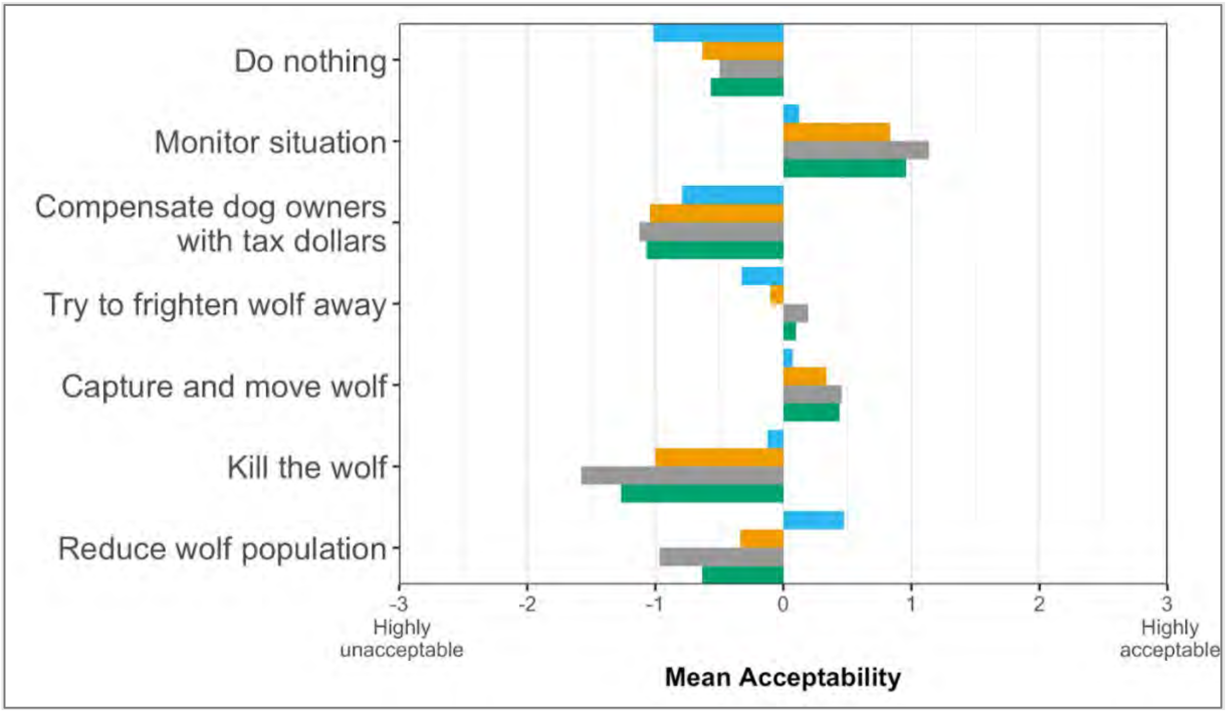

Figure 4-3 If a wolf (wolves) kills someone's pets, such as a dog in the yard, how acceptable is it for the Michigan DNR to take each of the following actions?

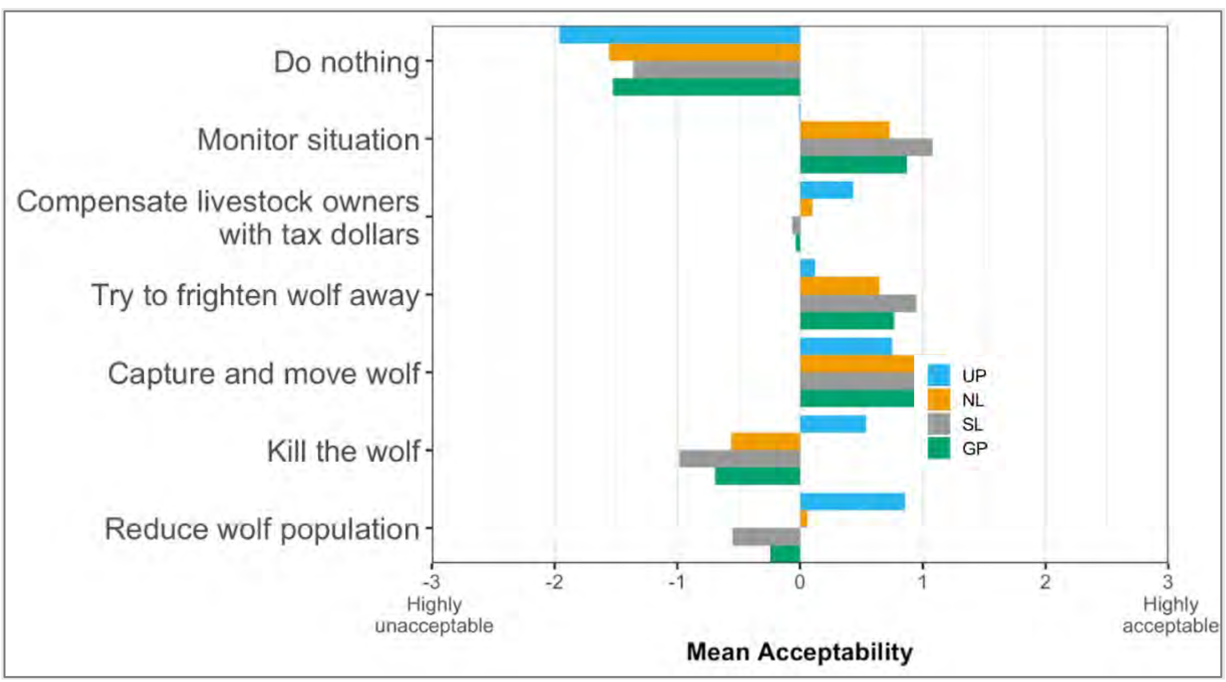

Figure 4-4 If a wolf (wolves) kills livestock, such as cattle, sheep, goats, or poultry, how acceptable is it for the Michigan DNR to take each of the following actions?

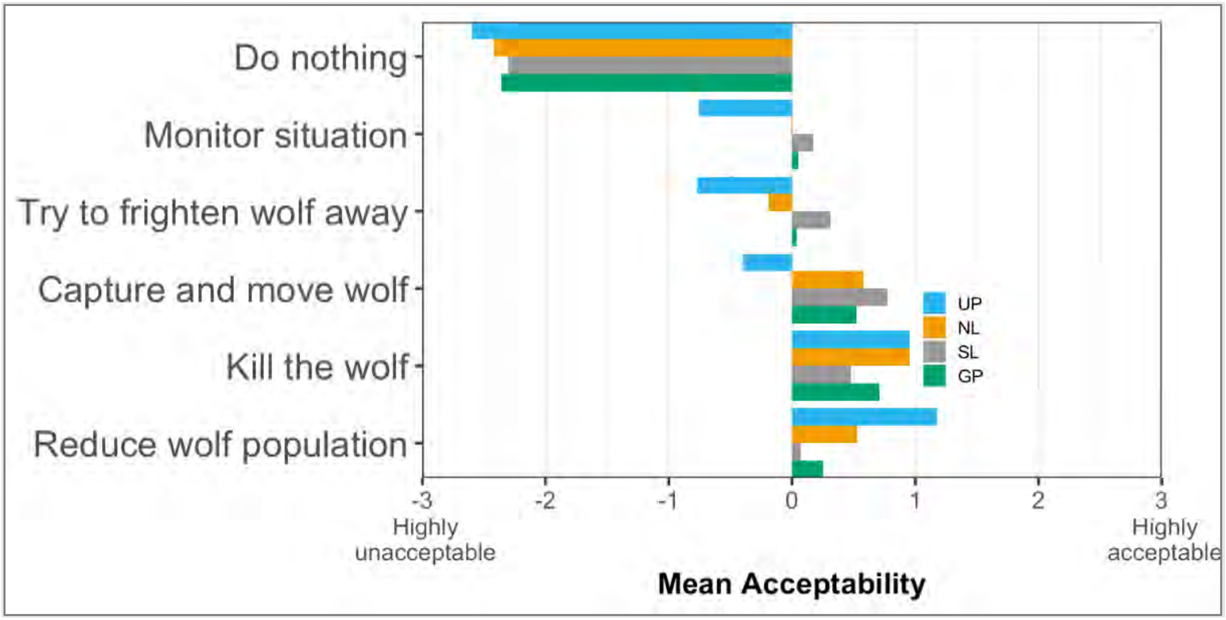

Figure 4-5 If a wolf (wolves) attacks a human, how acceptable is it for the Michigan DNR to take each of the following actions?

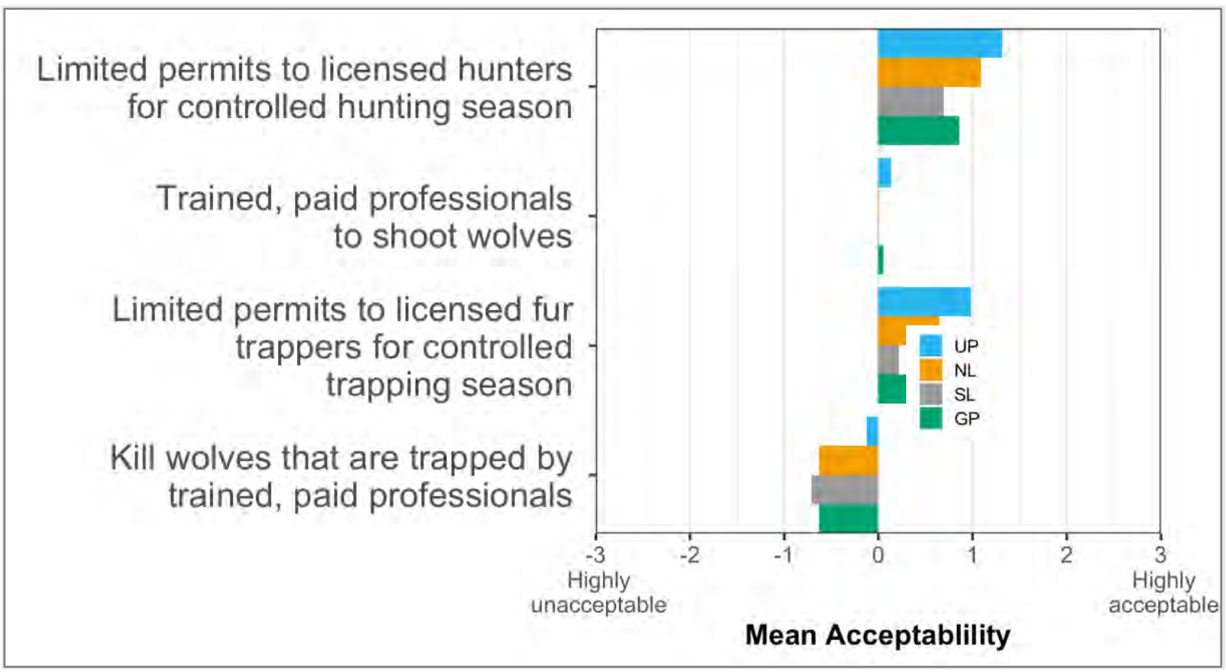

Figure 4-6 If a wolf or wolves had to be removed from an area for some reason, how acceptable are the following possible methods to you personally?

When examined together, the only interaction that elicited acceptability by the majority of respondents for killing wolves was attacks on humans (Figure 4-7). Passive management, or a "do nothing" alternative was the least acceptable action for every situation.

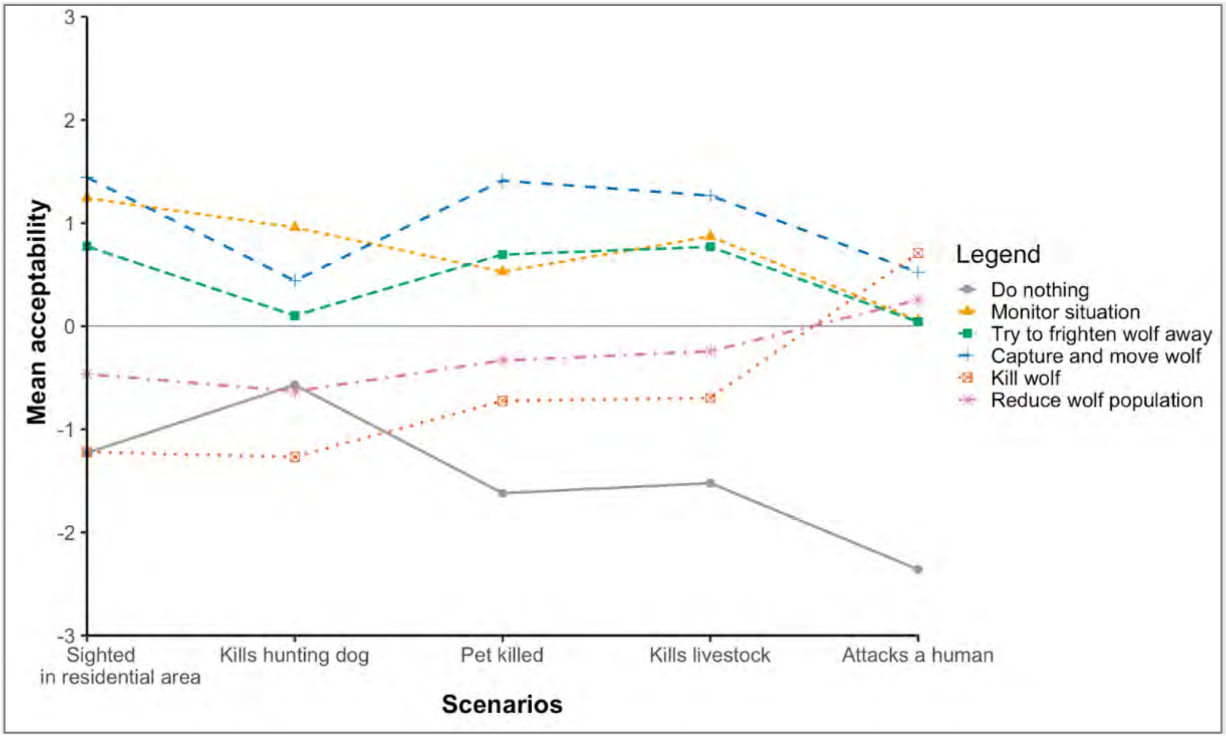

Figure 4-7 General public acceptability for wolf management strategies given various scenarios related to wolf behavior

Chapter 5 Wolf Depredation of Livestock and Dogs

Executive Summary

Wolves normally select wild ungulates including deer (*Odocoileus* spp.) and elk (*Cervus elaphus*), and secondarily smaller prey such as beaver (*Castor canadensis*) but sometimes kill or injure domestic animals (Newsome et al. 2016). Compared to rates of wolf depredation in Minnesota and Wisconsin, depredation in Michigan has been relatively rare. More than 900 livestock farms occur in the Upper Peninsula. From 1998 through 2021, 318 wolf depredations were verified on 104 of those farms. The number of wolf-depredation events varies annually and is often influenced by the activity of a single wolf pack. No wolf depredation has been documented in Lower Michigan.

Management of wolf depredation on livestock has included the use of non-lethal and lethal control measures implemented on a case-by-case basis. Techniques which may reduce or prevent wolf depredation of livestock include improved husbandry practices, fencing, livestock-guarding animals, scare tactics, aversive conditioning, and lethal control. The Michigan Department of Natural Resources (DNR) and its designated agents (i.e., USDA Wildlife Services) use many techniques which can be effective at preventing or deterring depredation. However, the effectiveness of some techniques may be temporary, and some techniques may fail to work altogether in certain situations.

Compensation for livestock lost to predators was put in place by Michigan legislature under Public Act 487, 2012, this program assists livestock producers by reimbursing them for losses attributable to wolf, coyote, or cougar depredation.

Under Michigan law, captive cervids are considered livestock and losses due to wolves are eligible for State compensation. However, these animals must be kept in fences that should prevent wolves from entering. If these captive animals are killed by wolves, the fence is typically not in compliance with the facility standards. In addition, because elk and deer are natural prey for wolves, some believe depredation should be handled differently than depredation of traditional livestock (e.g., cattle, sheep). Moreover, values for elk and deer are more subjective than for traditional livestock. Fewer interested citizens supported (33%) using tax dollars to compensate growers for the loss of deer or elk than for loss of traditional livestock.

Since 1996, wolves have killed or injured 142 dogs; approximately half (48%) of these incidents involved hounds used to hunt bears and about 73% involved hunting hounds (bear, rabbit/hare, and bobcat). Management of wolf depredation on dogs is generally more limited than for livestock depredation and focuses on prevention. More than 90% of respondents indicated that wolves pose at least some risk to pets, hunting dogs, and livestock, with the highest amount of risk associated with livestock, with only 2% of respondents indicating that wolves posed no risk to livestock.

However, the majority of respondents did not support killing wolves in the event of a wolf killing a pet (59.1%), hunting dog (68.5%), or livestock (56.9%). A plurality were unsupportive of reducing the wolf population in the case of a wolf killing a pet (49.1%), and a majority did not support reducing the wolf population in the event of the death of a hunting dog (55.6%). Respondents were split with respect to the acceptability of reducing the size of the wolf population in response to livestock depredation, with 40.5% stating this response was somewhat, moderately, or highly acceptable; 47.3% reporting unacceptable; and 12.2% indicating population reduction was neither acceptable nor unacceptable. Forty-eight percent of respondents indicated that using tax dollars to compensate livestock owners was somewhat, moderately, or highly acceptable. Lethal control was the most-supported management approach by livestock owners, in the event of pet, hunting dog, or livestock depredation. Livestock owners were highly supportive of killing wolves (76.1% indicate high, moderate, or somewhat acceptability of this approach) and reducing the size of the wolf population (72.5% indicate high, moderate, or somewhat acceptability of this approach).

Introduction

Wolves normally select wild ungulate including deer (*Odocoileus* spp.) and elk (*Cervus elaphus*), and secondarily smaller prey such as beaver (*Castor canadensis*), but sometimes kill or injure domestic animals (Newsome et al. 2016), including pets. When wolves kill or injure a domestic animal in Michigan, management options vary depending on whether the animal is considered livestock. As defined by the Michigan Animal Industry Act (Public Act 466 of 1988), livestock include but are not limited to cattle, sheep, new world camelids, goats, bison, privately owned cervids, ratites, swine, equine, poultry, aquaculture and rabbits. Under Michigan law, livestock do not include dogs and cats. Of the different species of pets, only dogs have been killed or injured by wolves in Michigan. In the following sections, livestock and dogs are discussed separately to highlight the differences in available management options.

Livestock Industry in Michigan's Wolf Range

Approximately 1,000 livestock farms (cattle, sheep and goats) occur in the UP (U.S. Department of Agriculture 2017 Census of Agriculture; Table 5-1). However, because of the way census data is collected, this estimate is certainly on the high side. For example, if a farm has cattle and sheep they would be counted once under each type of farm. Also, the term farm is used rather loosely since just ownership of a horse or chickens is counted as a farm. Farms in this region tend to be clustered because of soil and climatic conditions. Farms are concentrated in the eastern UP, with several other smaller clusters occurring in the northwest and southern portions of the UP (Figure 5-1). Cattle and calf operations are the most common type of farms in the region. The number of livestock present in the UP is approximately 15% of the number present in wolf range in either Wisconsin or Minnesota (Tom Meier, U.S. Fish and Wildlife Service, unpublished data).

In the 21 northern most counties in the NLP, there are approximately 2,100 livestock farms (cattle, sheep and goats) U.S. Department of Agriculture 2017 Census of Agriculture; Table 5-1). The majority of the farms in the NLP are concentrated around the shorelines of Lake Michigan and Lake Huron and in southern Missaukee County (Figure 5-1). As in the UP, cattle and calf operations are the most common type of farms. There is an average of one farm per 5.4 square miles in the northernmost 21 counties of the NLP versus an average of one farm per 15.7 square miles in the UP. If a wolf population becomes established in the NLP, the higher density of livestock farms in this region suggests the number of wolf depredations could be higher than what has been experienced in the UP.

Table 5-1 The type and number of farms in the Upper and Northern Lower Peninsulas of Michigan (U.S. Department of Agriculture 2017 Census of Agriculture).

Type of Farm	Upper Peninsula	Northern Lower Peninsula[a]
Livestock (Cattle, Sheep and Goats)	1069[b]	2081[b]
Cattle and calves	719[b]	1,517[b]
Sheep and lambs	202[b]	280[b]
All Goats	148[b]	284[b]
Hogs and pigs	143[b]	272[b]
Horses, ponies, mules, burros and donkeys	459[b]	1222[b]
Poultry and eggs	488[b]	1117[b]

[a]Northern Lower Peninsula is defined as the northernmost 21 counties in the Lower Peninsula.

[b]Some farms may have more than one type of livestock and would be counted in multiple categories.

Privately owned cervids (e.g., deer and elk raised in enclosures) are legally defined as livestock in Michigan. As of September 2021, the UP contained 23 registered Privately Owned Cervidae (POC) facilities. There was a total of 5,077 fenced acres containing roughly 2,100 captive cervids in the UP. The remainder of the State had 273 licensed facilities, for a total of 296 statewide, with over 62,100 acres of total fencing (enclosures) and roughly 27,000 animals, mostly white-tailed deer (Ryan Soulard, Michigan DNR, personal communication).

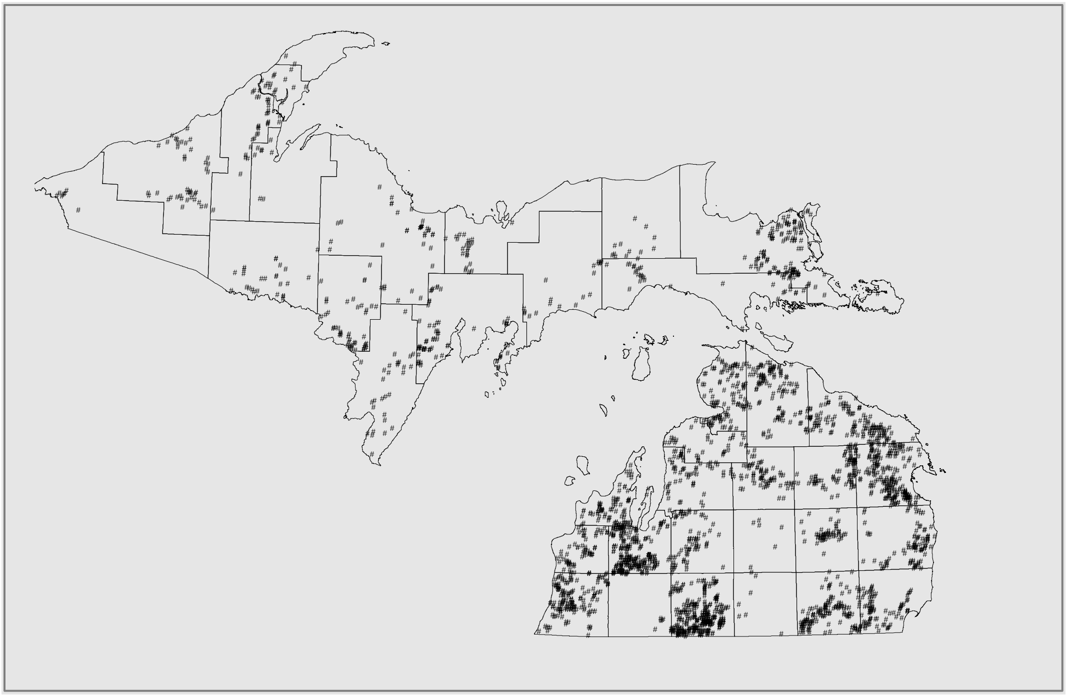

Figure 5-1 Distribution of livestock farms in the Upper and Northern Lower Peninsulas of Michigan (Brett Nelson, Michigan Department Agriculture, unpublished data).

Wolf Depredation of Livestock in Michigan

A depredation event consists of one or more animals' being killed or injured at a given time. From 1998 through 2020, 308 wolf depredation events on 103 different UP farms were verified (Table 5-2). To date, no wolf depredation events have been verified in the NLP. With the exception of depredation events involving poultry, the vast majority of events in the UP have involved the loss of a single animal. Approximately 10% of UP farms have experienced a depredation. Twenty-nine of the affected 103 farms have experienced more than one depredation event. The only time wolves have caused depredation on a privately owned cervid (white-tailed deer; *Odocoileus virginianus*) facility was in 2004 on two different facilities.

The number of livestock depredations has generally increased as the wolf population has grown until roughly 2012. Since 2012 there has been a general decrease with only six depredation events in each of the last four years (Table 5.2). Wolf depredation can be sporadic and annual fluctuations occur during the spring and late summer months. The high numbers of depredations recorded from 2010 to 2012 were driven by one farm with poor animal husbandry.

Experience in Minnesota suggests the number of wolf depredations would continue to increase as the population of wolves increases. From 1979 through 1998, the average number of wolf depredations in Minnesota increased from 10 to 100 per year as the wolf population doubled. The increase in wolf depredation was attributed to a combination of three factors: wolf range expansion, colonization of new areas within wolf range, and the learning by some wolves to kill livestock (Harper et al. 2005). However, in the UP there is a very weak correlation between the number verified livestock depredations and the number of wolves (R^2 value of .2842) (B. Roell, Michigan DNR, unpublished data). Suggesting that wolf depredations are driven by individual packs rather than the overall size of the wolf population.

Table 5-2 Number of verified wolf depredation events by livestock type and year in Michigan.

Year	Cattle	Sheep/Goats	Poultry	Cervids	Other[a]	Total
1998	3	0	0	0	0	3
1999	1	0	0	0	0	1
2000	2	1	2	0	0	5
2001	3	0	0	0	0	3
2002	4	0	1	0	0	5
2003	11	1	1	0	0	13
2004	7	2	0	2	0	11
2005	2	2	1	0	0	5
2006	8	1	1	0	0	10
2007	12	2	0	0	0	14
2008	10	0	3	0	1	14
2009	9	3	0	0	0	12
2010	43	2	1	0	0	46
2011	32	3	1	0	0	36
2012	31	4	0	0	0	35
2013	11	1	0	0	1	13
2014	23	0	0	0	0	23
2015	9	1	0	0	1	11
2016	22	2	0	0	0	24
2017	5	0	0	0	1	6
2018	6	0	0	0	0	6
2019	5	0	1	0	0	6
2020	5	1	0	0	0	6
Total	264	26	12	2	4	308

[a]Other livestock include one horse, two pigs and rabbits.

Wolves are not the cause of all livestock depredations, from 2003 through 2020 wolves, caused 58% (291) of the documented livestock depredation events (Table 5-3). Coyotes caused 39% (193) of documented livestock depredation events, with the remaining 3% (17) caused by bears or domestic dogs. Sometimes the cause of death, particularly with cattle, is not caused by a predator. Young calves can be still born or die from nonpredator related causes and be fed on by predators. On rare occasion, the cause of death cannot be determined (B. Roell, Michigan DNR, personal communication). An undetermined cause of death is typically associated with a lack of evidence caused by the later stages of decomposition.

Table 5-3 Livestock depredation events in the Upper Peninsula of Michigan by predator from 2003 to 2020.

Year	Wolf	Coyote	Bear	Domestic Dog
2003	13	1	N/A	N/A
2004	11	4	N/A	2
2005	5	7	1	N/A
2006	10	8	N/A	2
2007	14	7	N/A	N/A
2008	14	12	N/A	N/A
2009	12	11	N/A	N/A
2010	46	12	4	N/A
2011	36	22	2	N/A
2012	35	16	2	N/A
2013	13	11	N/A	N/A
2014	23	16	2	N/A
2015	11	5	N/A	N/A
2016	24	9	N/A	N/A
2017	6	18	N/A	1
2018	6	8	N/A	N/A
2019	6	18	N/A	1
2020	6	8	N/A	N/A
Total	291	193	11	6

Current Management Responses to Depredation of Livestock

An integrated approach that incorporates non-lethal and lethal control measures, providing technical assistance on animal husbandry practices, and compensating livestock growers for verified losses has been used to manage wolf depredation in midwestern and western states (Fritts et al. 2003, Bangs et al. 2006). However, drawing strong conclusions on the relative effectiveness of various control measures is difficult because few rigorous studies have been conducted (Bruns et al. 2020).

Complaints of wolf depredation of livestock require on-site visits by Michigan DNR or USDA Wildlife Services staff. In addition to verifying the cause of death, the visits provide opportunities to assist livestock growers by providing technical assistance on animal husbandry practices that may reduce future wolf depredations. However, neither Michigan DNR nor U.S.D.A Wildlife Services has the authority to enforce regulations regarding livestock practices that may reduce wolf–livestock conflicts. The use of death/carcass pits is illegal under Public Act 239 of 1982 but reports from field staff conducting depredation investigations indicate this law is not routinely enforced.

Compensation for livestock lost to predators was put in place by the Michigan legislature under Public Act 487 of 2012, it also established the Michigan Department of Agriculture and Rural Development (MDARD) as the lead agency responsible for responding to claims of livestock depredation caused by wolves, coyotes, or cougars. The MDARD recognized that the DNR and any of its designated agents (USDA-WS) has the expertise and staff capacity to perform the necessary field investigations to determine the cause of depredations prior to indemnification. The DNR and the MDARD agreed that it was in the best interests of all concerned to enter into a Memorandum of Understanding to effectively and efficiently implement the provisions of Public Act 487.

Under Public Act 487, after a verified wolf depredation event the MDARD shall reimburse the farm, for each animal included in the claim, 100% of the fair market value, on the date of the appraisal, for the market in which the animal was intended; not to exceed $4,000.00 for each animal. For the first time it also allowed indemnification for missing animals which are paid if there is a history of losses to the owner of livestock as evidenced by a prior payment by the department due to the death or injury of livestock from wolves. Payments for missing animals are not counted as verified wolf depredation.

Prior to 2012 there were two sources of funding used to compensate growers for losses of livestock to wolves. The indemnification program was still administered by MDARD and first became available in 1998 and paid 100% of the value of the animal at the time of loss. The funding for this program was identified in the MDARD's annual budget appropriation. Thus, funding could vary from year to year, but in general it was consistent. The legislation allowed the MDARD to seek reimbursement from the DNR for these costs, but this request was rarely made. Stipulations for using this fund still required livestock depredations to be verified by the DNR or its designated agents (i.e., U.S.D.A Wildlife Services) before the MDARD paid compensation.

The second source of funding was established in 2000 by private sources. These private funds were provided by Defenders of Wildlife and one citizen. In total this source provided for just over $10,000. This private fund was used to augment the MDARD payments for young-of-the-year livestock that are killed during the summer. The private fund paid the difference in value at the time of loss and the fall market value. These private funds were administered for the State by the International Wolf Center and by May 2010 all the money had been disbursed.

Through 2020 the funding sources in Michigan have paid almost $195,000 for losses of livestock (Table 5-4). Annual payments have generally increased as the wolf population has grown. Annual compensation payments have been much lower in Michigan than in either Minnesota or Wisconsin (Figure 5-2).

Table 5-4 Payments for wolf depredation of livestock by year and fund in Michigan.

Year	MDARD[a] ($)	IWC[b] ($)	Missing ($)	Penalty[c] ($)	Total ($)
1998	612.50	N/A	N/A	N/A	612.50
1999	400.00	N/A	N/A	N/A	400.00
2000	850.00	N/A	N/A	N/A	850.00
2001	1,450.00	750.00	N/A	N/A	2,200.00
2002	3,081.00	567.50	N/A	N/A	3,648.50
2003	4,370.00	350.00	N/A	N/A	4,720.00
2004	4,575.00	860.00	N/A	N/A	5,435.00
2005	1510.00	380.00	N/A	N/A	1,890.00
2006	1,765.00	825.00	N/A	N/A	2,590.00
2007	5,564.75	1,095.00	N/A	N/A	6,659.75
2008	7,264.90	1,700.00	N/A	N/A	8,964.90
2009	3,526.50	1,170.00	N/A	N/A	4,696.50
2010	20,026.50	2,355.01	N/A	N/A	22,381.51
2011	15,754.50	N/A	N/A	N/A	15,754.50
2012	20,530.00	N/A	N/A	N/A	20,530.00
2013	3,260.00	N/A	1,550.00	0.00	4,810.00
2014	17,666.66	N/A	11,333.34	0.00	29,000.00
2015	14,300.00	N/A	12,330.00	4,987.50	31,617.50
2016	12,520.00	N/A	1,225.00	0.00	13,745.00
2017	2,412.50	N/A	0.00	0.00	2,412.50
2018	2,120.00	N/A	4,500.00	0.00	6,620.00
2019	1,665.00	N/A	250.00	0.00	1,915.00
2020	3,459.02	N/A	0.00	0.00	3,459.02
Total	148,683.83	10,052.51	31,188.34	4,987.50	194,912.18

[a]MDA - Michigan Department of Agriculture and Rural Development; see text for description

[b]IWC - Private fund administered by the International Wolf Center

[c]Penalty - If the MDARD fails to make the indemnification payment within a 45-day time period, the person is entitled to receive from the department twice the amount of the original claim.

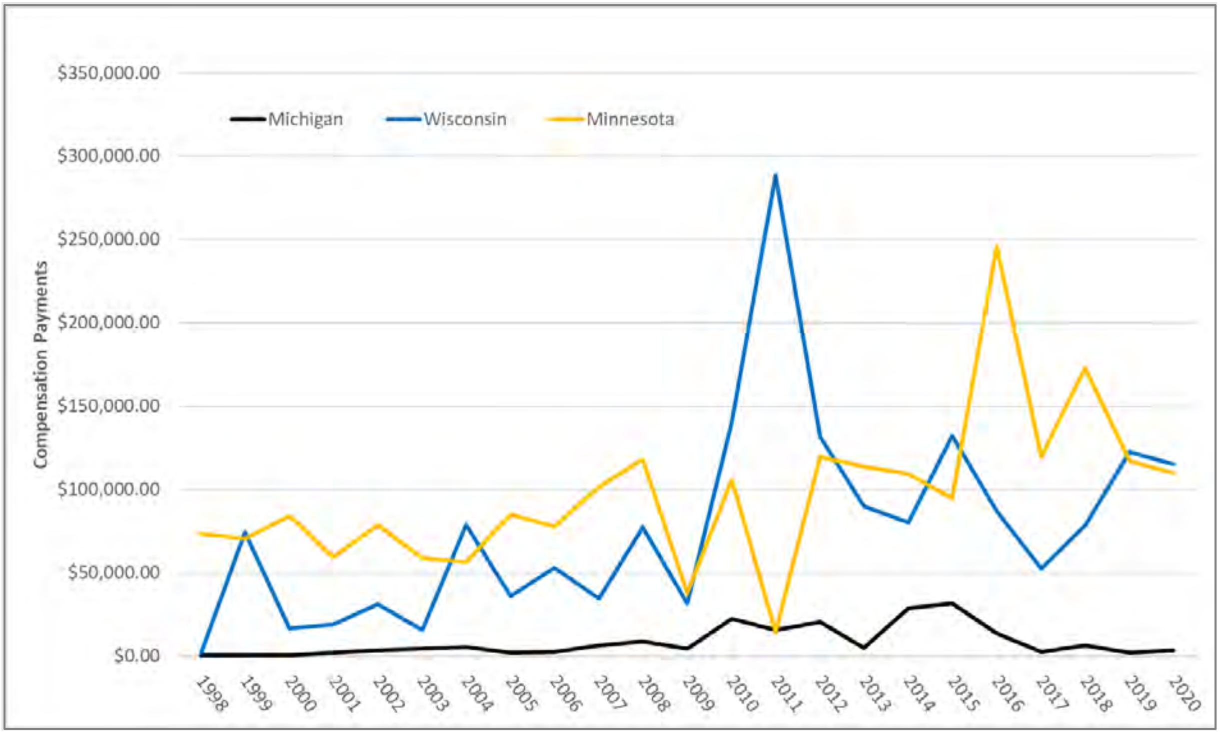

Figure 5-2 Compensation paid for wolf depredation of domestic animals in Michigan (MI), Wisconsin (WI) and Minnesota (MN), 1998–2020.

From 1998 to April 2003, when wolves were classified by the U.S. Fish and Wildlife Service as an endangered species, the Michigan DNR and its designated agents (i.e., USDA Wildlife Services) were limited to using non-lethal control techniques to respond to verified wolf depredations. In some cases, light/siren scare devices were deployed, but the primary management response was to trap and relocate wolves from farms that experienced losses. Twenty-three wolves were trapped and relocated from five farms during 1998–2003. One of these animals returned to the same farm a few years later and was translocated for a second time. These animals were radio-collared and released in areas where there was adequate prey and no known resident wolf packs. Overall, the translocations appear to have been generally effective in preventing further depredation by these animals. Only two of the 23 translocated wolves were associated with a second livestock depredation, and even in these cases, it was not clear whether these animals were responsible for the depredation. In both cases, control activities failed to capture the translocated animals and the wolves remained in these areas and no further depredation occurred. An important drawback of the relocation technique is that the wolves do not stay in the vicinity of the release sites; none of the translocated wolves established a territory that included their release site. Also, given the widespread wolf distribution across the UP at this time, suitable release areas no longer exist. Finally, residents have expressed opposition to the release of problem wolves near their communities.

In April 2003, the U.S. Fish and Wildlife Service reclassified wolves in Michigan and other parts of the United States from endangered to threatened (U.S. Fish and Wildlife Service 2003). A 4(d) rule accompanied the reclassification and authority was granted to allow State, Federal, and tribal agencies to use lethal control when responding to wolf depredation of domestic animals (livestock and pets). The Michigan DNR developed and implemented guidelines for responding to livestock depredations under this authority (Michigan Department of Natural Resources 2022b). During the 22-month period the 4(d) rule was in effect, nine wolves were killed in response to verified depredation events.

In early 2005, a U.S. District Court judge enjoined and vacated the Federal rule that reclassified wolves from endangered to threatened status. As a result, wolves were returned to federally endangered status and Michigan lost the ability to use lethal control.

In April 2005, Michigan was issued a sub-permit under a U.S. Fish and Wildlife Service Region 3 permit (under Section 10(a)(1)(A) of the Federal Endangered Species Act) to kill a maximum of 20 wolves for depredation control during 2005. Under that authority, two additional wolves were killed. In September 2005, a U.S. District Court judge invalidated the Federal sub-permit, on the basis the U.S. Fish and Wildlife Service issued the sub-permit without providing sufficient public notice and opportunity for public comment.

In September 2005, Michigan re-applied for a Section 10(a)(1)(A) permit to allow non-lethal, injurious harassment (e.g., rubber bullets) and limited lethal control in response to confirmed depredation events. The permit was issued on May 8, 2006. It authorized the Michigan DNR and its designated agents (i.e., USDA Wildlife Services) to kill a maximum of 40 wolves annually in response to confirmed depredation events. In August 2006, a Federal District Court abolished the lethal control portion of the 10(a)(1)(A) permit for both Wisconsin and Michigan. During the roughly three and half months when the permit was active seven wolves were killed.

In January 2007, Michigan received a new Section 10(a)(1)(A) permit which did not include any lethal control authority for animals causing depredation issues. However, in February 2007 wolf delisting in Western Great Lakes Distinct Population Segment was published into the Federal Registry and became affective 30 days later (March 12, 2007), so a Section 10(a)(1)(A) permit was not issued. This wolf delisting was also challenged in court and wolves returned to the Endangered Species List on September 29, 2008. During the 18 months while wolves were delisted 22 wolves were killed for livestock protection purposes. Michigan Public Act 290 was passed into law in late 2008, this act allows anyone under certain circumstances to use lethal control on wolves when they were in the act of preying upon livestock. No wolves were killed under Public Act 290 before wolves returned to the list of Endangered Species.

In January 2009, the USFWS announced that the delisting of wolves would be written into the Federal Registry on January 27, 2009 and delisting would take effect roughly 30 days later (February 27, 2009). Delisting was then put on hold until further review by the Obama administration. The delisting for the Western Great Lakes distinct population segment took effect on May 4, 2009. This delisting only lasted until September 16, 2009 when wolves were once again returned to the list of Endangered species. During the roughly four months that wolves were delisted one wolf was killed for livestock protection.

Once again in January 2012 wolves were removed from the list of Federally Endangered Species. While wolves were delisted the DNR was able to implement provisions of the 2008 Michigan Wolf Management Plan which directed the DNR to develop a wolf control permit which would allow livestock owners to use lethal control on wolves. However, wolves were returned to the list of Federally Endangered Species on December 19, 2014 when an U.S. District Court in Washington, D.C. issued an opinion immediately placing wolves in Michigan and Wisconsin back on the federal endangered species list and wolves in Minnesota back on the federal threatened species list. During the approximate three years wolves were delisted, lethal control for protecting livestock was used on one wolf killed by USDA Wildlife Services, 17 under control permits, and 14 were killed under Public Act 290 of 2008.

Wolves were once again federally delisted on January 4, 2021 and were returned to the List of Endangered Species on February 10, 2022. During the 12 months wolves were delisted in 2021, seven wolves were killed under control permits and USDA-WS killed two others, all in an effort to control livestock depredation.

Options for Managing Depredation of Livestock

Several potential approaches that may help minimize wolf depredation of livestock have been identified through literature review and consideration of experiences and approaches in other states and countries. These approaches include non-lethal and lethal methods, or combinations of both.

Livestock Husbandry Practices

Depredation risk tends to increase with herd size, distance from people and buildings, proximity to thick cover, and carcasses left in the open (Sillero-Zubiri and Switzer 2004, Pimenta et al. 2017, Amirkhiz et al. 2018). Thus, husbandry practices influence the risk of wolf–livestock conflicts (Ciucci and Boitani 1998, Breck et al. 2011, Pimenta et al. 2017). Provided below are examples of livestock husbandry practices that can be used to minimize conflicts.

- Quickly remove dead livestock. Dead and decaying livestock can attract wolves (Petroelje et al. 2019). Carcass disposal is especially important during the winter because carcasses remain edible for a longer period. Disposal alternatives include using pre-dug holes, composting, and using commercial landfill. Rendering facilities do not exist in Michigan.

- Protect young animals. Delay turnout of young or pregnant livestock until they are more capable of eluding predators (Fritts 1982, Breck et al. 2011, Pimenta et al. 2017). Pasture larger, hardier livestock in rougher, distant pastures; pasture young, vulnerable livestock in areas with sparse vegetation cover, close to buildings and humans, or keep indoors for up to 3 months (Mason 2001, U.S. Department of Agriculture 2002a, Pimenta et al. 2017).

- Monitor livestock. Regular human presence may discourage predators from stalking or hunting livestock. Livestock are more vulnerable to depredation during dawn, dusk and night; at small operations, corralling during these time periods may help decrease wolf–livestock conflicts.

- Avoid problem areas. When possible, avoid using pastures with a history of depredation and pastures next to dense cover or rough terrain. When possible, thin or clear a buffer around remote pasture.

- Keep records. Accurate, up-to-date record-keeping systems help to identify when and where depredation problems may occur (Kansas Extension 1980).
- Avoid feeding wildlife. Baiting and feeding can attract and concentrate natural prey and thus can attract wolves (Fritts 1982).

Fencing as Barriers against Depredation

Few fences are absolute predator barriers, though they can be effective in reducing livestock depredation (Bruns et al. 2020, Samelius et al. 2021). Fencing effectiveness is determined by density and behavior of predators in the area, availability of prey, size of pasture, type of terrain, season, design of the fence, quality of construction, and maintenance (Gegner 2002, Bruns et al. 2020). Fencing height of 1.2 m or higher is recommended (Reinhardt et al. 2012, Salvatori and Mertens 2012). Fencing may be cost-effective when the potential for predation is high and fencing can be combined with other management techniques (e.g., fencing and guard dogs; U.S. Department of Agriculture 2002a, b). Fencing height of 1.2 m or higher is recommended (Reinhardt et al. 2012, Salvatori and Mertens 2012). Electric fences can be more effective than non-electric fences (Green et al. 1994, Khorozyan and Waltert 2019). Existing fences can be retrofitted with electric strands to help exclude wolves (Mason 2001). Fencing is most successful when it is strung before a wolf has established a pattern of movement (Gegner 2002).

Several limitations are associated with using fencing as a barrier to exclude wolves. Fencing is expensive and may be appropriate only for small areas, such as calving or breeding grounds. Some predators may attempt to dig or climb over a fence (U.S. Department of Agriculture 2002a, Bruns et al. 2020). Fences require regular maintenance (Bruns et al. 2020) because of rust, rot, frost heaves, and vegetation growing and falling onto them. Snow and frozen ground can greatly reduce the effectiveness of electric fencing (Gegner 2002).

Livestock-guarding Animals

Livestock-guarding animals may prevent depredations and should be viewed as a supplement to other forms of predator control (Potet et al. 2021). It is not the guard animals' fighting ability that protects a flock or herd, but rather their interference with the normal predatory routine (Smith et al. 2000). Effective guarding animals may help livestock owners by: (1) reducing depredation, (2) reducing labor (lessening the need for night corralling), (3) alerting owners to disturbances, (4) protecting the family and property, and (5) allowing for more efficient use of pastures (U.S. Department of Agriculture 2002b, Gehring et al. 2010a).

Several drawbacks are associated with the use of guard animals. Guard animals, including dogs, are vulnerable to wolf attacks (U.S. Department of Agriculture 2002b). In some cases, they may be killed by wolves while protecting livestock. Also, guard animals do not guarantee positive results because they could roam away from livestock or injure livestock themselves (U.S. Department of Agriculture 2002b). Guard animals may not be suitable in very large pastures (U.S. Department of Agriculture 2002b). Finally, guard animals are expensive to purchase and some require extensive training (e.g., Gehring et al. 2011, VerCauteren et al. 2012).

The use of guard dogs to deter wolf depredation has been tried in Minnesota with limited success (Fritts et al. 1992) but reduced use of pastures containing livestock by wolves and coyotes in Michigan (Gehring et al. 2010b). Coppinger and Coppinger (1995) recommended guard dogs be established with livestock in possible conflict zones long before the wolves' arrival, giving the guard dogs time to establish their territories. More research is needed to fully evaluate the effectiveness of guard dogs (Shivik 2001, Gehring et al. 2010).

Scare Tactics

Wolves can be frightened by strange odors, sights or sounds (U.S. Department of Agriculture 2002). Examples of scare tactics include night-lighting corrals, propane exploders, flagging (fladry) and movement-activated guard devices (e.g., Bangs et al. 2006, Iliopoulos et al. 2019). In the eastern Upper Peninsula, wolf use of livestock pastures was reduced when protected by fladry (Davidson-Nelson and Gehring 2010).

Scare devices have the best success when they are triggered by the problem behavior, rather than applied continuously. Wolves can become habituated to these devices after repeated exposure and using diverse techniques can improve effectiveness (Stone et al. 2017). Varying the position, appearance, duration or frequency of the scare devices, or using the devices in various combinations, may increase effectiveness (Kansas Extension 1980; Young et al. 2019).

Aversive Conditioning

An aversive stimulus causes discomfort, pain or an otherwise negative experience. Examples of aversive stimuli previously used on wolves include rubber bullets, cracker shells, and electronic dog-training collars (shock collars) (e.g., Bangs et al. 2006, Hawley et al. 2013). In Wisconsin, Hawley et al. (2009) and Rossler et al. (2012) demonstrated reduced use of shock zones (i.e., baited areas) by wolves with shock collars. Effectiveness of aversive conditioning is dependent on learning; wolves may not associate aversive stimuli with their problematic behavior. However, depredations can continue despite the use of aversive stimuli; predators sometimes redirect attacks to avoid sites treated with highest concentrations of repellents (Mason 2001).

Lethal Control

Killing wolves to reduce livestock depredations is generally tolerated by the public, but it is regularly scrutinized if non-lethal techniques are available (Fritts et al. 2003, Browne-Nuñez et al. 2015). Trapping and shooting are the most common methods used to kill depredating wolves. Poison can be effective for this purpose, but poor public perception, legal constraints (under both Michigan and Federal law), and the chance of killing non-target species (e.g., Hervieux et al. 2014) make the use of poisons socially unacceptable (e.g., Proulx et al. 2015).

There are few robust studies examining the effect of lethal control of wolves on livestock depredations. Bradley et al. (2005) compared the effectiveness of no removal of wolves, removal of partial packs, and removal of full packs in the western United States. The median time following control before the next depredation was 19 days for no removal, 64 days for partial pack removal, and 730 days for full pack removal (Bradley et al. 2015). These authors found full pack removal reduced future depredations by 79% over 5 years compared to no removal of wolves. Wielgus and Peebles (2014) estimated the number of livestock depredated in a given year was influenced by the number of wolves controlled the previous year in Idaho, Montana, and Wyoming from 1987 to 2012. A more rigorous re-analyses of these data estimated that for each wolf killed the previous year would decrease the number of cattle killed in the current year by 1.9%, and number of sheep killed by 3.4% (Poudyal et al. 2016). However, Poudyal et al.

(2016) also noted that for each wolf killed there was an estimated 2.2% increase in the number of sheep killed that same year and suggested the increase in sheep depredations was short term. In the Upper Peninsula of Michigan, Santiago-Avila et al. (2018a, b) found no difference in efficacy between lethal and nonlethal wolf control for reducing livestock depredations at the section, township, or neighborhood of township scales. However, Santiago-Avila (2018a) noted multiple limitations of the data that were available and recommended rigorous scientific evaluations before implementing interventions.

Santiago-Avila et al. (2020) reported increased prevalence of unreported poaching of wolves in Wisconsin during periods of policy change providing increased ability to use lethal wolf control in defense of human property or safety, though it is not possible to quantify poaching that is not documented. However, Olson et al. (2015) demonstrated that poaching of radio-collared wolves declined in association with lethal control in Wisconsin. Chapron and Treves (2016a, b) attributed reductions in wolf population growth in Wisconsin and Michigan during periods of state authorized legal control to poaching. However, multiple research teams countered this assertion from multiple conceptual, biological, and analytical perspectives (Olson et al. 2017, Pepin et al. 2017, Stien 2017) to which the original authors were provided opportunity to respond (Chapron and Treves 2017a,b).

When wolves are not federally protected and under State management authority in Michigan, lethal control methods could be implemented either by government agents, licensed hunters and trappers, or livestock growers. The potential effectiveness of control by livestock growers is unknown.

Wolves in Michigan were removed from the Federal List of Threatened and Endangered Species on Jan. 4, 2021 but placed back on the Federal List on Feb. 10, 2022. In the fall of 2008, House Bill No. 5686 was signed into law; this allows citizens to use lethal control on wolves that are in the act of killing or wounding livestock. This bill, now known as Public Act 290 of 2008, is available to citizens only when wolves are federally delisted.

Additionally, livestock producers that meet certain requirements can request livestock producer control permits to kill a specified number of wolves on their property. Livestock producer control permits are issued by the local wildlife biologist or Law Enforcement Division District Law Supervisor after receiving approval from the Wildlife Division Regional Supervisor, in accordance with Department guidelines (Michigan Department of Natural Resources 2020).

Hunting can also be considered as a method to mitigate livestock depredation. In 2013, we reviewed our records of conflicts including livestock and pet depredations and human safety issues. Then using guidance from the Michigan Wolf Management Plan we held the most conservative hunt for wolves in any of the six states that allowed wolf hunting in the lower 48 states. There is scientific uncertainty relative to the use of wolf hunting as a conflict management tool because most wildlife managers do not have experience with this approach for wolves, and none of the other wolf hunts in the lower 48 states have had the same management objectives as the Michigan hunt. However, there are examples where human-wildlife conflicts have been directly reduced by decreasing population density via hunting, such as in American black bears (Garshelis et al. 2020) and Eurasian lynx (*Lynx lynx*, Herfindal et al. 2005) There is also a growing body of evidence that animal behavior is influenced by the perception of the risk of predation (e.g., Lima and Bednekoff 1999, Ferrari et al. 2009). Researchers have extended this work by examining the effect of human hunters on wildlife behavior. Unfortunately, no studies have examined the behavioral response of wolves to hunting. However, studies on other species have shown that human hunting sometimes alters animal behavior including increasing wariness. Examples of species whose behavior has been altered by hunting include white-tailed deer (Kilgo et al. 1998), monkeys (5 species; Croes et al. 2006), capercaillie (Thiel et al. 2007) duikers (3 species; Croes et al. 2006), reindeer (Reimers et al. 2009), mallard ducks (Dooley et al. 2010), and elk (Proffitt et al. 2009). In Michigan, we had the opportunity to examine the effect of hunting on elk wariness when the State reinitiated hunting in 1984 after almost 20 years with no legal harvest. We found that the short-duration elk hunts caused elk to become more wary of human approach (Bender et al. 1999). Our field observations of other hunted species, including predators such as coyotes and bears, also indicate that most animals are wary of human presence. In addition, in Ontario where wolf hunting and trapping have a long history, wolves are wary of people and rarely display fearless behavior outside of protected areas where human take is prohibited (Brent Patterson, Ontario Ministry of Natural Resources, personal communication).

Compensation Programs

Property damage by wildlife has been considered by some to be a natural risk in agricultural production. However, endangered-species status limits personal options for abating livestock losses due to wolves. Therefore, compensation programs were designed to assist livestock growers by reimbursing them for losses, with the intention of increasing overall public acceptance for wolf recovery programs (e.g., Treves et al. 2009). The expected success of compensation programs was based on the assumption that the problem is largely an economic one. Although livestock growers desire and have received economic relief through compensation programs (e.g., Wisconsin; Agarwala et al. 2010), research has shown the programs have not substantially improved tolerance for wolves (Naughton-Treves et al. 2003, Agarwala et al. 2010).

Additional Considerations for Privately Owned Cervids

Legal Aspects

The Michigan Animal Industry Act (Public Act 466 of 1988) defines privately-owned cervids (POC) as livestock. An informal legal opinion from the Michigan Attorney General office concluded that as long as POC were classified as livestock, all rules, procedures and compensation programs that apply to livestock also apply to POC (Doug Erickson, Michigan DNR, personal communication). However, because cervid species are the natural prey of wolves, wolf depredation of cervids living behind a fence at often unnaturally high densities may be considered a special case.

Compensation for depredation of POC presents another set of issues. Whereas average appraised values for common species of livestock such as cattle, sheep and swine are well documented, values for POC are more subjective. Current law restricts compensation to no more than $4,000.00 per animal.

Practical Aspects

The Operational Standards for Registered Privately Owned Cervidae Facilities (OSRPOCF 2000) stipulate that fencing for captive cervid enclosures “must be maintained in a condition to prevent ingress or egress of any cervidae species,” and that “the ground edge of the fencing shall remain at or below ground level at all times.” Further, openings in the fence are “not to exceed 6 inches square” and “gates must be adjusted seasonally, or more often if necessary, to ensure that the bottom of the gate extends no higher than 8” from the ground along the entire length.” If a POC facility is in compliance with these fencing standards, it is unlikely an adult wolf could gain entry to a captive cervid enclosure to prey on the occupants. Although small pups could gain entry under a gate or through the mesh of fences, it is extremely unlikely such a small wolf could or would kill a captive cervid, even a fawn or calf.

If a wolf preys upon a captive cervid, some means of ingress into the enclosure must exist, and it is likely the fence is not in compliance with operational standards. If a fence is not in compliance, the argument could be made that the grower should not be compensated for any depredation losses because biosecurity has been compromised and the facility is in violation. On the other hand, there have been instances where a fence has been breached in spite of the due diligence of the facility owner. Liability concerns arise when, for instance, the fence is adjacent to State-owned land. A tree blown down on a fence, creating an unintended opening and allowing a predator to enter before the owner finds it, raises the issue of whether the owner should be held to the same standard as someone who neglects routine fence maintenance or other biosecurity measures for extended periods. This situation would also raise the question of whether the State is responsible because it owns the adjacent land on which the downed tree previously stood. Contingency funds for compensation of the facility owner under such extenuating circumstances could be helpful, but a source for those funds is unknown at this time.

Wolf Depredation of Dogs in Michigan

Between 1996 and 2020, 142 wolf attacks on domestic dogs were verified in Michigan; 101 dogs were killed as a result of those attacks (Table 5-5). Yearly losses vary and can be disproportionately influenced by the actions of a single pack. Of the 101 wolf-related dog deaths verified since 1996, 77% involved hunting hounds (bear and rabbit/hare). Some dogs were attacked in close proximity to their owners' residences.

Table 5-5 Wolf depredation of dogs by year in Michigan.

Year	Dogs Killed	Dogs Injured
1996	1	0
1997	0	0
1998	0	0
1999	2	1
2000	0	0
2001	3	0
2002	4	1
2003	8	3
2004	4	1
2005	2	1
2006	4	0

Year	Dogs Killed	Dogs Injured
2007	3	2
2008	0	0
2009	2	0
2010	1	3
2011	12	5
2012	7	3
2013	13	4
2014	16	1
2015	3	0
2016	2	1
2017	2	1
2018	4	6
2019	3	5
2020	5	3
Totals	101	41

Reasons Wolves Attack Domestic Dogs

There are several reasons why wolves sometimes attack dogs. Research in Minnesota indicates wolves may attack dogs because of interspecific aggression or because wolves view dogs as prey (Fritts and Paul 1989). Research suggests rural residents who live near the edge of small communities in areas with large wolf populations are more likely to experience wolf–dog conflicts (Fritts and Paul 1989). According to Fritts and Paul (1989), small- to medium-sized dogs, which may be particularly excitable and vocal, are more likely to provoke an attack by wolves. Evidence from some wolf attacks on dogs suggests that wolves may seek out dogs rather than encounter and attack dogs at random (Fritts and Paul 1989).

In Wisconsin, wolves killed or injured 177 dogs actively engaged in hunting activities and 33 outside of hunting situations not in the act of hunting during 2015-2020 (Wisconsin Department of Natural Resources 2021). During the same time period in Michigan, wolves killed or injured 31 dogs actively engaged in hunting activities and 4 outside of hunting situations (Brian Roell, Michigan DNR, personal communication). Most dog depredation events in Michigan occurred during August-September during dog training and hunting seasons for black bears and when wolf pups and adult wolf activity is centered on rendezvous sites (Edge et al. 2011b, Treves et al. 2002), like the timing of peak depredation events in Wisconsin (July-September; Olson et al. 2014). In both Wisconsin and Michigan, most wolf attacks were on dogs used for hunting or being trained for hunting, particularly bear hunting (Ruid et al. 2009). In Wisconsin, wolf depredations of hunting dogs were more likely to occur in areas nearer to wolf pack core areas, and in areas with larger pack sizes and greater amounts of publicly accessible land and less developed land (Olson et al. 2014). Bump et al. (2013) found that longer periods of bear baiting resulted in greater risk of hunting dog depredation by wolves.

Current Management Responses to Depredation of Dogs

Reports of wolf depredation of dogs are investigated with the same techniques used for livestock depredations. From 1996 to 2020, the federal status of wolves has changed multiple times which in turn changed the Michigan DNR's authority to use lethal control in response to dog depredation events. Authority to use lethal control in response to wolf depredation of dogs was temporarily provided under the 4(d) rule and a Section 10(a)(1)(A) permit, and when wolves were removed from the list of federally Endangered Species. The Section 10(a)(1)(A) permit did not allow the use of lethal control when wolves kill dogs that are free roaming on, hunting on, or training on public lands. Lethal control could be used when wolves kill dogs that are leashed, confined, or under the owners' control on the owners' land under a 10(a)(1)(A) permit. No wolves were killed for causing dog depredation under authority granted under the 4(d) rule or Section 10(a)(1)(A) permit.

In 2008 Public Act 318 was passed into law. This Act allows anyone under certain circumstances to use lethal control on wolves when they were in the act of preying upon domestic dogs when wolves are not listed as a federally Endangered Species. When wolves are not listed as an Endangered Species, Michigan DNR guidelines state that the use of lethal control may be used when non-lethal methods are determined to be ineffective in specific areas where a wolf attacks on free-ranging hunting dogs has been verified. However, staff will not authorize lethal control as a preventative measure where attacks have not yet occurred. Wolf control permits like the ones used for livestock farms are not available to take wolves that kill dogs that are free roaming, running at large, hunting, or training on public lands, and all other lands open to public hunting. When status of wolves allowed lethal control, eight wolves were killed because of dog depredation, and one was killed by authority granted by PA 318 of 2008.

Options for Managing Wolf Depredation of Dogs

Perhaps the best approach to reduce the risk of a wolf–dog conflict when hunting with dogs is to avoid areas that are currently being used by wolves. Preventive methods have not been rigorously evaluated. However, the Wisconsin DNR have assembled the following recommendations (https://dnr.wi.gov/topic/WildlifeHabitat/wolf/guidance.html):

Hunting dogs

Hound dogs used for hunting bear, coyotes, bobcat, and raccoon are perhaps at greatest risk of being attacked by wolves. Dogs used for bird hunting are less likely to be attacked. Wolves normally avoid people and are less likely to approach dogs that are in the visual or auditory range of humans.

Hounds often hunt some distance from hunters, and their baying sound may present a challenge to the territorial wolves. The highest risk of wolf depredation to dogs seems to occur in July through September, and a moderately high risk occurs in December. These periods signal the summer rendezvous period, and the approach of the winter breeding season.

Reducing conflict:

Avoidance of wolves is the best way to minimize conflict, but because wolves are so widespread, total avoidance may not be possible. Although wolves have large territories, they concentrate a lot of activity in specific areas, such as the rendezvous sites. One of the keys to minimizing wolf problems with dogs is to avoid areas with concentrated wolf use.

Ways to reduce conflict include:

- find information on the DNR dog depredation webpage or from your local wildlife biologist about possible wolf attacks on dogs in your hunting area;
- attempt to stay as close to dogs as possible;
- move two or three miles from any rendezvous site, if possible, before releasing dogs;
- avoid releasing dogs at bear baits recently visited by wolves;
- avoid areas with high concentrations of wolf tracks, scats and remains of wolf kill;
- learn to recognize your own dog tracks so that you can distinguish them from wolf tracks; and
- use bells or beepers on dogs.

Pet owners

Attacks on dogs in residential areas represent a special kind of wolf depredation to domestic animals. In trailing hound situations, attacks generally occur with the pack defending pups at rendezvous sites. However, these types of attacks (defending rendezvous sites) would normally only occur from mid-June through late September when rendezvous sites are in use. In the case of dogs attacked near homes, these may occur throughout the year and outside the summer rendezvous period. In these specific cases, wolves are probably attacking dogs in defense of the edges of their territory, or they may be preying on dogs as food sources.

Ways to reduce conflict include:

- Do not leave pets outside overnight unless they have a sturdy kennel.
- Avoid feeding deer near your home.
- Do not leave cat or dogs food outside at night.
- Do not deposit table scraps or animal products near home sites.
- Keep pets on a leash or in visual/auditory range on walks and vocalize regularly including the use of whistles.
- Do not allow dogs to roam at large.
- Avoid releasing dogs outside for bathroom breaks after dark except in areas with good lighting or that are fenced.

Attitudes of Michigan Residents

This section discusses relevant findings from the 2021 public-attitude study (Riley et al. 2022) and its survey of 359 livestock growers in the UP and the NLP based on a list provided by Michigan State University Extension, Michigan Sheep Producers Association, and UP Ag Connections email lists. Details of the study methods and additional results are presented elsewhere in this document (i.e., Chapter 2).

Livestock Producers

Livestock producers expressed concern about the amount of risk posed by wolves to livestock such as cattle, sheep, goats, or chickens. More than 62% of livestock owners indicated that wolves present a large amount of risk to livestock, and 23.0% indicated that wolves pose at least a moderate amount of risk to livestock. Respondents were asked to express their support or opposition to several management options when applied to different scenarios of wolf issues, including a wolf killing livestock such as cattle, sheep, goats, or poultry. The management options offered were to: do nothing, monitor the situation, frighten the wolf, capture and move the wolf, kill the wolf, reduce the size of the population; and in the livestock depredation scenario, use tax dollars to compensate the producers.

Livestock producers supported the use of tax dollars to compensate for livestock depredation, with 34.4% indicating it is a highly acceptable approach, 25.0% indicating a moderately acceptable approach, and 18.8% indicating a somewhat acceptable approach. However, the strongest support among livestock producers for management actions to address livestock depredation were killing the problem wolves (44.6% highly acceptable, 21.7% moderately acceptable) and reducing the size of the wolf population (46.2% highly acceptable, 15.4% moderately acceptable). Less support was reported for compensating owners for the loss of hunting dogs or pets, with only 16.7% and 12.5% reporting this as a highly acceptable approach, respectively.

General Public

(Note: Discussions of the general public results are based on weighted data. The special mailing of this survey to a subset of livestock growers was not included in this analysis.)

Importance of wolf depredation on livestock, hunting dogs and pets

General public respondents expressed some concern about the amount of risk posed by wolves to livestock such as cattle, sheep, goats, or chickens. About 38.9% of respondents indicated that wolves present a large amount of risk to livestock, and 37.2% indicated that wolves pose a moderate amount of risk to livestock. Risk was perceived as greater to livestock than to pets, such as dogs around the house, or to hunting dogs. About 18.9% of respondents indicated that wolves present a large amount of risk to pets, such as dogs around the house, and 33.9% indicated that wolves pose a moderate amount. An estimated 21.4% of respondents indicated that wolves present a large amount of risk to hunting dogs, and 33.4% indicated that wolves pose a moderate amount.

Public acceptance of depredation-control strategies

Respondents were asked to express their support or opposition to several management options when applied to different scenarios of wolf issues, including depredation scenarios such as a wolf killing livestock such as cattle, sheep, goats, or poultry; a wolf killing a pet, such as dogs around the house; or a wolf killing a hunting dog. The management options offered were to: do nothing, monitor the situation, frighten the wolf, capture and move the wolf, kill the wolf, reduce the size of the population; and in the livestock depredation scenario, use tax dollars to compensate the producers.

They were asked whether various management options were acceptable, on a scale of highly acceptable to highly unacceptable. Mean acceptable for each option is provided in the following figures (4.1, 4.2, 4.3, 4.4, 4.5, 4.6). The majority of respondents did not support killing wolves in the event of a wolf killing a pet (59.1%), hunting dog (68.5%), or livestock (56.9%). However, when examined by region, UP respondents were supportive of killing wolves in the event of the death of a pet or livestock and were supportive of reducing the wolf population in the event of the death of a pet, livestock, or a hunting dog. In the event of the death of livestock (Figure 5-3), the most acceptable management method was to capture and relocate the wolf, followed closely by monitoring the situation and frightening the wolf. The least acceptable method was doing nothing. In the event of the death of a hunting dog (Figure 5-4), the most acceptable management method was to monitor the situation; however, the most acceptable method for UP residents was reducing the wolf population. Among the general public, the least acceptable method was killing the wolf. In the event of the death of a pet, such as a dog in someone's yard, (Figure 5-5), the most acceptable management method was to capture and move the wolf, although UP residents were also highly supportive of reducing the wolf population. Among the general public and when examined by region, the least acceptable response was to do nothing.

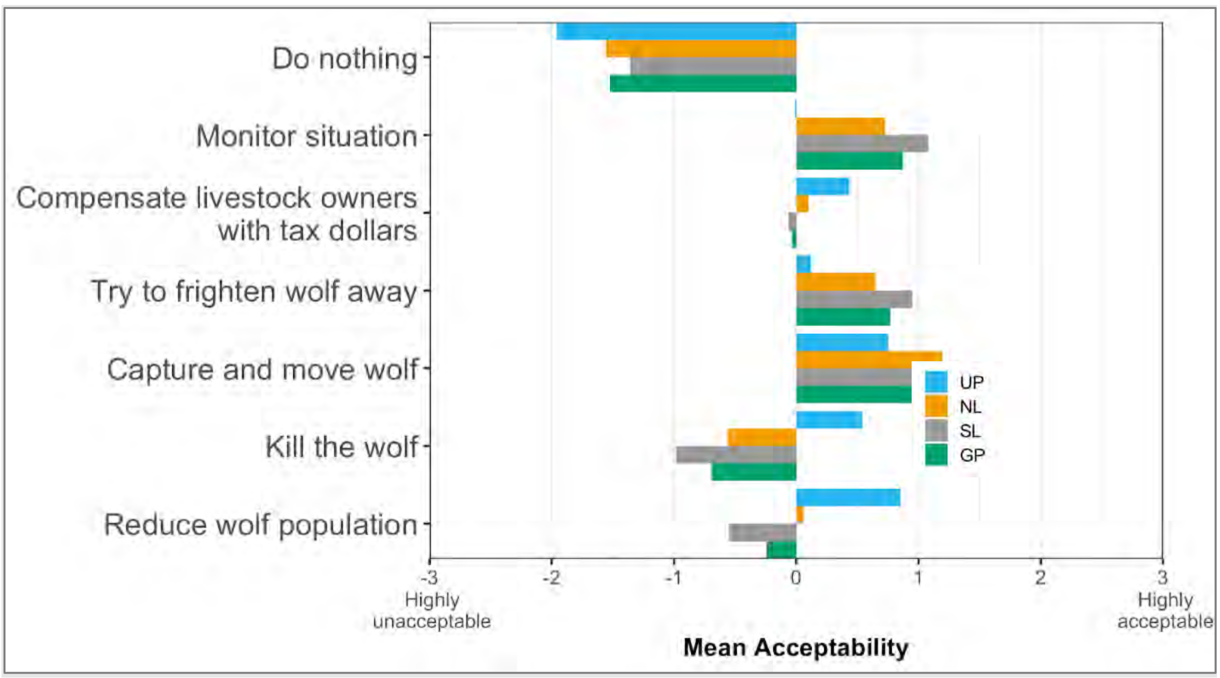

Figure 5-3 If a wolf (wolves) kills livestock, such as cattle, sheep, goats, or poultry, how acceptable is it for the Michigan DNR to take each of the following actions?

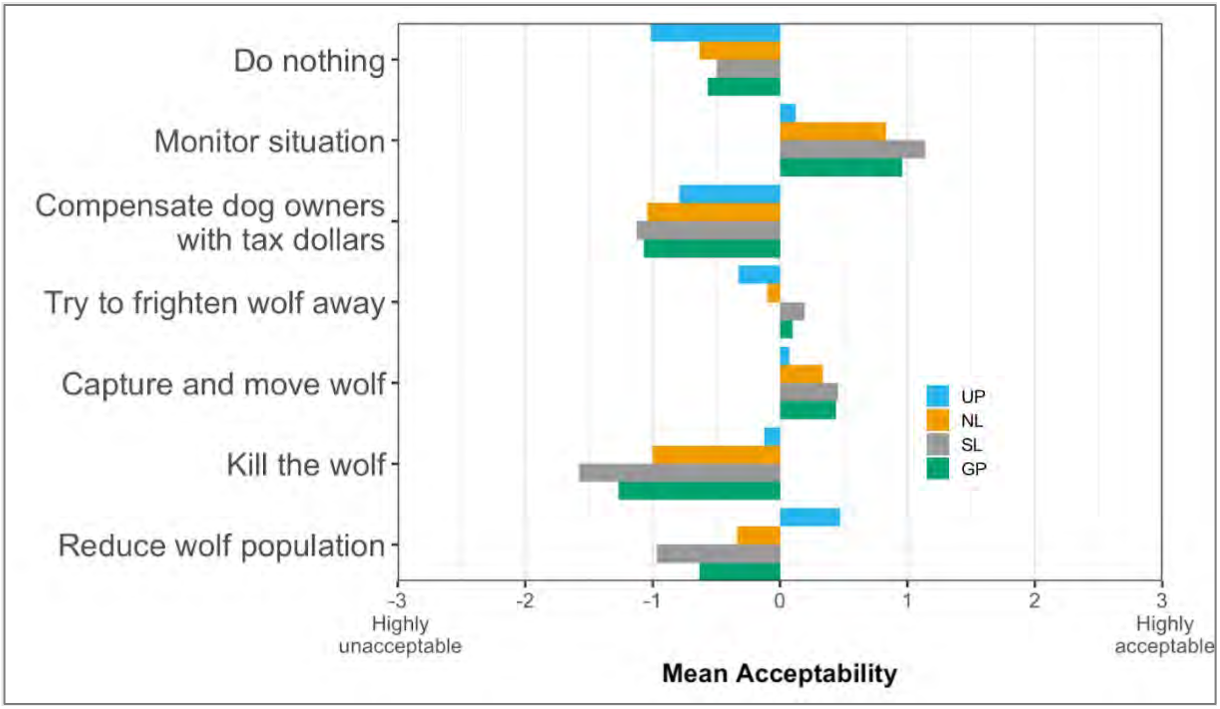

Figure 5-4 If a wolf (wolves) kills a free-ranging hunting dog while out hunting or training, how acceptable is it for the Michigan DNR to take each of the following actions?

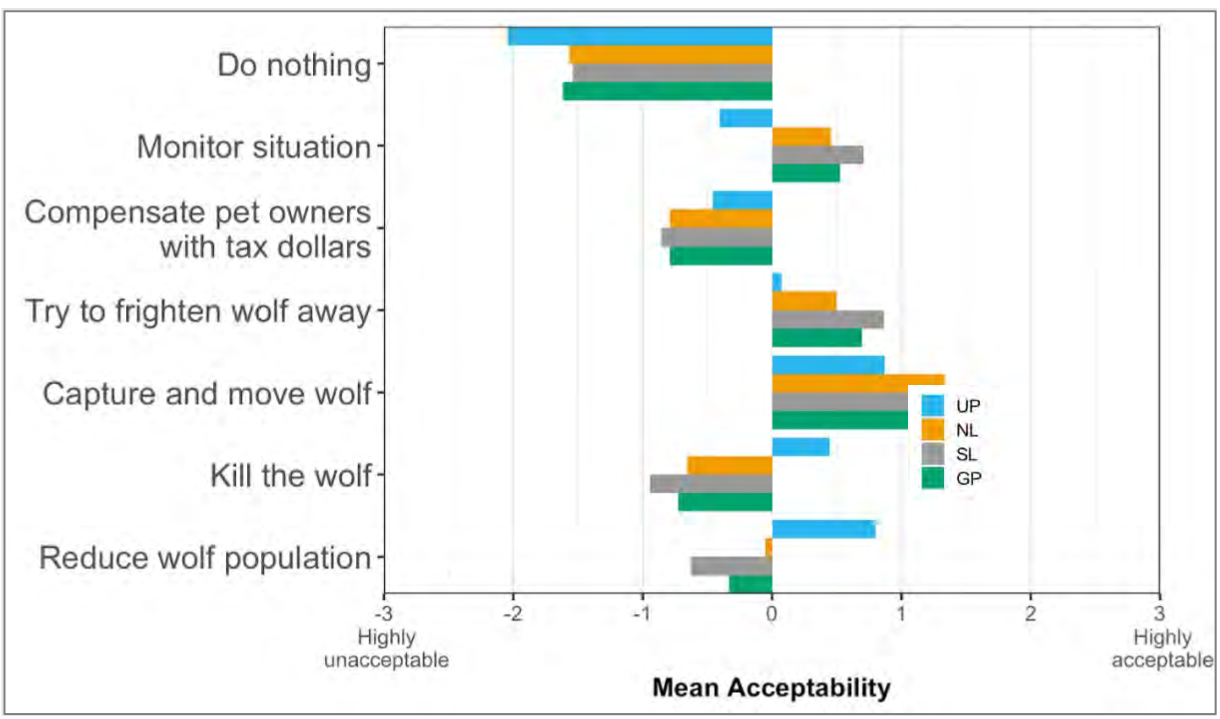

Figure 5-5 If a wolf (wolves) kills someone's pets, such as a dog in the yard, how acceptable is it for the Michigan DNR to take each of the following actions?

Chapter 6 Wolf–Prey Relationships

Executive Summary

The impact of wolves on prey populations has been the subject of numerous scientific studies and has been debated at length by the public. There is agreement in the scientific community that the relationship between wolves and prey is complex and broad descriptive statements cannot be made. In some cases, wolves limit prey populations and in other cases they do not. Ungulates such as deer (*Odocoileus* spp.), moose (*Alces alces*), elk (*Cervus elaphus*) and caribou (*Rangifer tarandus*) are the primary prey species for wolves. The relationship between wolves and prey is influenced by a host of factors that can vary both spatially and temporally. Factors that must be considered include the number of different prey species available, the relative density of wolves and prey in an area, the response of wolves and prey to changes in prey numbers, and the effects of weather and disease on wolves and prey.

Wolves and prey have evolved together and prey species have developed physical and behavioral traits that help them avoid predation. Wolves tend to select more vulnerable individuals, such as the young, old or sick. However, vulnerability is not necessarily determined by age or poor health. Environmental factors, such as deep snow conditions, can make otherwise healthy animals vulnerable to predation. If wolves only killed individuals that would have otherwise soon died from other causes, wolves would have no effect on the prey population. The extent to which wolf predation is additive to other forms of prey mortality has not been adequately studied in wolf–deer systems like that found in Michigan.

Public attitudes concerning wolf–prey relationships vary among regions in Michigan and between licensed hunters and the general public. Licensed deer hunters provided mixed responses regarding the competition between hunters and wolves for deer and the role of wolves in maintaining healthy populations of deer. While 21.43% of hunters strongly agreed that wolves are an important part of the Michigan environment, 19.81% strongly disagreed. 24.6% of hunters either moderately or strongly agreed that wolves help maintain healthy deer populations, 30.9% strongly or moderately disagreed. Overall, more deer hunters strongly or moderately agreed that it is important to maintain a wolf population in Michigan (46.0%) than strongly or moderately disagreed (22.05%). Compared to the general public, deer hunters indicated that wolves are a higher risk to the populations of white-tailed deer, with 77.3% indicating wolves present a large or moderate risk. In comparison, 66.9% of the general public indicated wolves present a large or moderate risk to those deer. However, when responses are parsed by regional subsample, the general republic respondents from the UP perceive even more risk than deer hunters, with 83.5% indicating wolves present a large or moderate risk to populations of white-tailed deer.

Introduction

The influence of wolves on prey populations has been the topic of much research and debate. Ungulates are the primary prey of wolves (Newsome et al. 2016), and the most common ungulate in Michigan is white-tailed deer (*Odocoileus virginianus*) (e.g., Kautz et al. 2020).

Prey Selection

Wolves prey on a variety of wildlife species, and predation on those species often changes seasonally and geographically (Van Ballenberghe et al. 1975, Voigt et al. 1976, Fritts and Mech 1981, Potvin et al.

1988, Fuller 1989, Mech and Peterson 2003, Adams et al. 2010, Newsome et al. 2016, Gable et al. 2018a, Homkes et al. 2020; Kautz et al. 2020, Michigan DNR unpublished data). In general, prey abundance, distribution, vulnerability and behavior influence the importance of a particular prey species to wolves or other predators as a food source. Further, wolf group size can influence prey selection; pairs of wolves killed more roe deer (*Capreolus capreolus*) than moose compared to packs of wolves (Sand et al. 2016). Wolf prey selection patterns overall appear determined by prey vulnerability which is related to prey size and age (Mattioli et al. 2011).

In Minnesota, white-tailed deer, moose (*Alces alces*) and beaver (*Castor canadensis*) make up the majority of wolf diet (Van Ballenberghe et al. 1975, Barber-Meyer and Mech 2016). In this area, the predominance of deer remains in wolf scat indicates deer are the principal prey throughout the year despite relatively high densities of moose (Van Ballenberghe et al. 1975). However, in extreme northeastern Minnesota, wolves were the dominant source of mortality for moose calves (Wolf et al. 2021) and calves were more important prey than deer fawns during summer (Chenaux-Ibrahim 2015). Seasonal variation in prey selection, or prey switching, is known to occur in most wolf populations and is usually associated with changes in prey abundance or vulnerability. For example, during spring and early summer months, beaver become an important food source (Van Ballenberghe et al. 1975, Voigt et al. 1976, Fritts and Mech 1981, Potvin et al. 1988, Fuller 1989). In June and July, wolves are thought to prey heavily on deer fawns and moose calves when they are more vulnerable and occur in relatively high densities (Voigt et al. 1976, Fritts and Mech 1981, Fuller 1989). In 2019-2020, greatest prevalence of moose calves in wolf scats collected during summer on Isle Royale occurred shortly after peak moose parturition, then declined through September (National Park Service, unpublished data). However, importance of various prey to wolves can vary spatially and temporally (e.g., Chenaux-Ibrahim 2015, Barber-Meyer and Mech 2016).

In the Upper Peninsula, white-tailed deer and moose constitute the ungulate prey available for wolves (e.g., Kautz et al. 2020, Michigan DNR unpublished data). However, moose are rarely preyed upon by wolves, probably due to the lack of overlap in distribution with wolf pack territories (particularly early in wolf recolonization), the low abundance of moose in comparison to deer, and differences in vulnerability (Michigan DNR, personal communication). Therefore, wolves in Michigan effectively function in a single-ungulate prey species system, particularly during winter (e.g., Kautz et al. 2020). Specifically, research in Michigan indicates deer are the primary prey item for wolves during winter (e.g., Vucetich et al. 2012; Kautz 2019, 2020). More recently in the Upper Peninsula of Michigan, wolves were found to be an important predator of adults but not fawns. Of 363 radio-collared deer fawns monitored to 16 weeks of age, 12 died of known wolf predations, representing 8% of known-cause mortalities and 3.5% of the total fawn sample (Kautz et al. 2019, MDNR, unpublished data). In this same study, coyotes were the single greatest predator of fawns (13.1% of the total fawn sample), followed by black bears (*Ursus americanus*; 7.8%), and bobcats (*Lynx rufus*; 5.4%); unidentified predation was 8.8% of the total fawns sample (Kautz et al. 2019, MDNR, unpublished data). In contrast, of wolves killed 56 of 424 radio-collared adult female deer, representing 42% of known cause mortality and 8.6% of the total population (Kautz et al. 2020, MDNR, unpublished data). However, most adult female predations occurred in late winter and early spring with a third or more deer in poor nutritional condition, suggesting wolf predation was partly compensatory (Kautz et al. 2019, MDNR, unpublished data).

Though ungulates are the dominant prey of wolves worldwide (Newsome et al. 2016) and the Great Lakes region (DelGiudice et al. 2009), early studies in the Upper Peninsula found wolves ate shrews, snowshoe hares, red squirrels (*Tamiasciurus hudsonicus*), mice, ruffed grouse, crayfish and grass in addition to white-tailed deer (Stebler 1944, 1951). Following white-tailed deer in dietary importance, smaller mammals such as beaver, snowshoe hare and ruffed grouse (Bonasa umbellus) comprised part of the diet of wolves (Huntzinger et al. 2004). More recently, prey identified at 164 wolf "cluster" sites (i.e., a group of locations from a GPS-collared wolf suggesting extended time spent in an area) during summer was comprised primarily of white-tailed deer (76.8%; 12.2% adult, 64.6% fawn), followed by beaver (3%), muskrat (*Ondatra zibethicus*; 2.4%), raccoon (*Procyon lotor*; 2.4%), snowshoe hare (1.8%), coyote (*Canis latrans*; 1.2%), ruffed grouse (*Bonasa umbellus*; 1.2%), Canada goose (*Branta canadensis*; 0.6%), wild turkey (*Meleagris gallopavo*; 0%), and unknown species (4.3%) (MDNR, unpublished data).

Typically, in multiple-prey systems where several species of ungulates are available, wolves can be maintained at higher densities than in single-prey systems (Fuller 1990, Kunkel and Mech 1994). In multiple-prey systems, the more-vulnerable species commonly predominates as the main food source for wolves (Van Ballenberghe et al. 1975, Fritts and Mech 1981, Mattioli et al. 2011), which corresponds with wolves reducing their risk of injury during predation events (Stahlberg et al. 2017). Prey can use various predator-avoidance strategies (e.g., distribution, behavioral traits, migration) to help them sustain predation losses to their populations and give them a limited temporal or spatial advantage over other species of prey (Seip 1995, Kautz et al. 2022a, b). For example, in Alaska, where moose, Dall sheep (*Ovis dalli*) and caribou (*Rangifer tarandus*) are available to wolves, moose were the most common prey consumed. Although smaller, Dall sheep and caribou use predator-avoidance strategies that reduce their risk of predation (Ballard et al. 1987). Annual productivity of prey species also affects their ability to sustain predation losses.

In the Upper Peninsula, white-tailed deer during summer used areas with greater human activity, presumably to reduce fawn predation risk (Kautz et al. 2022a). Though overall predation risk was reduced, human-caused mortality of fawns (e.g., vehicle collisions) were greater and largely negated the effects of reduced predation risk (Kautz et al. 2022a). Species with low productivity, such as caribou, moose and elk (*Cervus elaphus*), appear more likely to be regulated by wolves or experience declines associated with wolf predation than are species with higher productivity, such as deer (Seip 1995). Existing data on wolf impacts to deer populations in single-prey systems are limited and attempts to extrapolate wolf impacts on other ungulate species to deer can be problematic.

Prey Defenses

Prey and predators coevolved. As a result, prey possess physical and behavioral adaptations for avoiding predation; indeed, most wolf hunts are unsuccessful (Mech 1970). The effectiveness of these adaptations allows prey populations to be sustained, even in areas with robust predator populations. In deer, physical defensive traits include speed, agility, visual, olfactory and auditory acuity, cryptic coloration, antlers, and lack of scent in the very young (Mech and Peterson 2003). Behavioral defenses include vigilance, vocalizations, visual signals, synchronized birthing in local populations, and aggression (Mech and Peterson 2003). Deer also learn to change their behavior to avoid encounters with wolves: they may alter their use of an area, become more vigilant, or group together (Voigt et al. 1976, Mech and Peterson 2003; Kautz et al. 2022a). Further, in the Upper Peninsula, Kautz et al. (2022b) determined that deer were able to alter daily activity to simultaneously maximize risk avoidance from predators and human along roads. Elk similarly avoided areas of high risk from wolves and cougars (Kohl et al. 2019). These changes in behavior may also affect deer sightability by humans and promote the assumption that deer populations have been heavily impacted by wolf predation.

Prey Vulnerability

Prey vulnerability influences predator selection by wolves (Mattioli et al. 2011, Stahlverg et al. 2017). Selection of more-vulnerable prey is more apparent when prey are abundant (Potvin et al. 1988) or when environmental conditions (such as snow depth) create an advantage for predators by reducing the energy reserves of prey or decreasing their ability to escape (Mech et al. 1971**,** Nelson and Mech 1981, Kautz et al. 2020). Selective predation of deer by wolves in winter varies in relation to deer nutritional condition, body size, and ability to cope with differing environmental conditions (Nelson and Mech 1986, Fuller 1991, Huntzinger et al. 2004, Kautz et al. 2020). For example, fawns in Minnesota (Fuller 1991) and Michigan (Huntzinger et al. 2004) were preyed upon more often than adults during winter. Deer in Michigan appeared most vulnerable to predation during late winter and early spring when in poor condition (Kautz et al. 2020). Fawns tend to have lower fat reserves, decreased mobility in deep snow, and are more likely to suffer from the effects of starvation compared to adults and yearlings, all of which predisposes them to predation. Mech and Frenzel (1971) showed adult male deer in poor condition after the fall breeding season experienced increased wolf predation during winter in Minnesota. By contrast, Huntzinger et al. (2004) found wolves killed adult male deer in proportion to their availability in the Upper Peninsula of Michigan. Studies in Minnesota showed adult deer killed by wolves were older and had more debilitating anomalies and pathological conditions than deer killed by hunters (Mech and Frenzel 1971**,** Fritts and Mech 1981). Similarly, adult deer killed by wolves in Michigan were generally older than deer killed by vehicles (Huntzinger et al. 2004). One study of wintering deer in Ontario (Kolenosky 1972) showed no difference in the average age of wolf-killed deer versus human-killed deer whereas a study in Quebec found that fawns and older deer were selected (Potvin et al. 1988).

Disease (e.g., chronic wasting disease [CWD]) can also potentially increase prey vulnerability to wolf predation (e.g., Brandell et al. 2022) but has not been rigorously tested in a wolf-prey system. In studies involving cougars, they did not appear to select for CWD-infected elk in South Dakota (Sargent et al. 2011). However, mule deer killed by mountain lions in Colorado were more likely to be infected with CWD than were hunter-killed deer in the same area (Krumm et al. 2009). Miller et al. (2008) found mountain lion predation of prion-infected mule deer was 4 times greater than predation of uninfected deer in Colorado.

Kill Rate

Extrapolating winter kill rates throughout the annual cycle is problematic because there is evidence of substantial seasonal variation in kill rates related to differences in prey vulnerability (Pimlott et al. 1969, Mech and Frenzel 1971, Kolenosky 1972, Nelson and Mech 1986, Huggard 1993, Huntzinger et al. 2003, 2004). Also, estimates of kill rates made from the air may be low because some kills may be missed when kills are made during the night, consumed quickly or located under thick conifer canopy. In Michigan, snow tracking of wolf packs has been used to estimate winter kill rates to avoid the potential biases of aerial counts. Kill rates of Michigan wolves have varied five-fold during winters of varying severity. Increasing snow depth and decreasing deer condition result in higher kill rates (Huntzinger et al. 2003, 2004). This finding is in agreement with other research which found higher kill rates in late winter (Mech 1977b, Fritts and Mech 1981, Dale et al. 1995). Predation of adult female white-tailed deer in the Upper Peninsula of Michigan was greatest during winter when deer were in poor nutritional condition (Kautz et al. 2020).

The average number of deer killed per year by an individual wolf has been estimated by several studies. Fuller (1989) calculated average annual consumption was 18.8 deer per wolf. Mech (1971) estimated the average wolf killed approximately 15 deer per year. Based on three studies of winter kill rates, Keith (1983) estimated an average annual kill rate of 16.6 deer per wolf. Pimlott (1967) estimated an average annual kill rate of 36.7 deer per wolf. These estimates were generally biased because they were winter studies. Kill rates in winter may not be equivalent to those in other seasons and also can vary throughout the winter (e.g., Vucetich et al. 2012) and in response to prey abundance (Zimmerman et al. 2015). For example, summer kill rates of moose can be higher due to the vulnerability of calves (Johansson 2004). Vucetich et al. (2012) estimated an average winter kill rate of 0.68 kill/pack/day in Michigan, representing about 7.7 kg of prey/wolf/day. Summer kill rates of deer have not been assessed. Information from Michigan suggests other studies may overestimate seasonal average kill rates by 50% (Vucetich et al. 2012).

Wolves have been documented to occasionally kill more prey than they can consume at one time (Mech 1966, Pimlott et al. 1969, Mech and Frenzel 1971, DelGiudice 1998, Zimmerman et al. 2015). This behavior, termed 'surplus killing,' is a rare occurrence that seems to be tied to unusually deep snow conditions (Fuller 1991, Mech and Peterson 2003) and pack size and prey abundance (Zimmerman et al. 2015). Wolves are an opportunistic predator and are accustomed to a feast-or-famine existence. It is suspected that when they encounter highly vulnerable prey, they take advantage of the opportunity to kill multiple animals. Although prey are not immediately fully consumed, wolves often return and use predated carcasses (Mech et al. 1998, Michigan DNR unpublished data).

Influence of Wolves on Ungulate Numbers

As previously discussed, ungulates are the primary prey of wolves. In some situations, wolves may significantly reduce local prey populations, whereas in others, the impact may be negligible (Mech and Peterson 2003). The wolf–prey relationship is complex and is influenced by many factors, including, but not limited to, the number of prey species in a system, the relative densities of wolves and prey (Kautz et al. 2019), the responses of both wolves and prey to fluctuations in prey densities, and the effects of environmental influences (e.g., winter severity, disease, habitat) on wolves and prey (Mech and Peterson 2003). Each of these factors varies geographically and temporally; thus, there is no general answer to the question of how wolves affect prey densities. As examples, Kautz et al. (2019) found that winter severity had a strong effect on adult female white-tailed deer survival and magnitude of predation. Melis et al. (2009) found that the effects of predation on roe deer densities was greater in areas of reduced environmental productivity. Persistent low deer winter abundance in northern Minnesota during a period of increasing forage was attributed to wolf predation and traditional deer migration patterns (Nelson and Mech 2006).

It is tempting to try to use estimates of kill rate to determine the effect of wolves on their prey. Unfortunately, this approach is problematic for at least two reasons. First, as discussed above, estimates of kill rate made during the winter should not be extrapolated to the snow-free periods of the year. Second, the extent to which mortality due to predation is additive or compensatory is unknown and undoubtedly varies in different areas and over time. Predation is compensatory when it substitutes for other forms of mortality prey would experience in the absence of predators (Ballard et al. 1987; Kautz et al. 2020). If predation was completely compensatory, all prey killed by wolves would have otherwise soon died from other causes. Evidence showing wolves tend to kill less fit individuals supports the notion that wolf predation is at least partially compensatory (Kautz et al. 2020). Predation is additive when it increases the overall mortality rate of prey.

Another factor that makes it difficult to determine whether wolves are limiting prey numbers is the presence of other predators capable of killing the same prey species. There is general agreement in the literature that the presence of a second predator in the system increases the probability predators could limit prey numbers (Mech and Peterson 2003). Indeed, elk calf survival was lower in areas with 4-5 predators compared to areas with 3 predators (Griffin et al. 2011). However, there may be an upper limit of prey mortality whereby an increasing number of predator species no longer influences overall predation rates. For example, fawn white-tailed deer predation rates were similar in areas with 2 or 3 predator species (Shuman et al. 2017). Fawn mortality rates in the Upper Peninsula with 4 predator species (Kautz et al. 2019) was similar to average white-tailed fawn mortality in forested areas of North America (Gingery et al. 2008). Indeed, white-tailed deer fawn mortality in the absence of predators can be as high as fawn mortality with predators present (Dion et al. 2020).

Influence of Wolves on Other Species

Wolves impact non-prey species in a variety of ways, often dictated by the degree of niche overlap and food abundance. Mid- and small-sized canids (coyotes: *Canis latrans*; foxes: *Vulpes* spp.) experience the most interference competition with wolves. This competition typically results in avoidance behavior by or direct displacement or killing of the subordinate species (Peterson 1995b, Ballard et al. 2003). Of the canids, niche overlap is greatest between coyotes and wolves (Peterson 1977), but both species can co-exist at low densities or when spatially segregated (Peterson 1995b, Ballard et al. 2003). In Minnesota, coyotes were generally absent in wolf core areas (Berg and Chesness 1978). On Isle Royale, coyotes were extirpated shortly after the arrival and establishment of wolves (Peterson 1977). Wolves also limited coyote populations in Yellowstone National Park (Crabtree and Sheldon 1999). Fowler et al. (2021) found some support for wolves limiting coyote occurrence in the Upper Peninsula. Densities of wolves and coyotes in the Upper Peninsula were inversely related, with coyote diet, space use, and daily activity less variable in areas of lower wolf densities as apparent means to allow their coexistence (Fowler et al. 2022). However, in other areas, coyotes maintain relatively high densities in areas with wolves (Ballard et al. 2003). Negative interactions between wolves and brown bears (*Ursus arctos*; Smith et al. 2004) and black bears (*U. americanus*) occur (Fremmerlid and Latham 2009), including at den or kill sites (Ballard et al. 2003). Wolves were reportedly responsible for cougar mortality and usurping prey killed by cougars (Kortello et al. 2007). In general, small-mammal populations are not influenced greatly by wolf numbers, but beaver declines were documented on Isle Royale in the 1980s when the species was targeted heavily by wolves due to declines in the primary prey (Shelton and Peterson 1983). Changes in plant communities through "trophic cascades" following wolf recolonization were reported in Wisconsin (Bouchard et al. 2013, Callan et al. 2013) and following wolf introduction in Yellowstone National Park (e.g., Beschta and Ripple 2010, Ripple and Beschta 2012, but see Allen et al.

2017 for general counter discussion). Importantly, wolves increase availability of food for scavengers (Mech 1970, Vucetich et al. 2004, Klauder et al. 2021, Michigan DNR unpublished data).

Ungulate Populations and Wolf Control Programs

The National Research Council (1997) conducted an extensive review of ten predator-control projects designed to increase the number of ungulates available for human harvest. Eight of these projects involved a reduction of wolves using aircraft and two involved ground-based wolf control. The National Research Council (1997) concluded that problems in how these predator-control experiments were conducted limited how much could be learned from these efforts. Nevertheless, the Council found that "wolf control . . . resulted in prey increases only when wolves were seriously reduced over a large area for at least four years." It cautioned that the experiments that appeared to be successful used methods (e.g., aerial shooting) that were not politically acceptable. It is not known from these studies whether wolf numbers can be reduced sufficiently with less-controversial methods. Further, the Council found that wolf populations usually recovered to pre-control levels within 4 or 5 years after control efforts had stopped. The design of these experiments did not allow investigators to determine whether the control programs resulted in higher ungulate numbers that lasted long after predator control was stopped.

The studies reviewed by the National Research Council investigated the effects of wolf control on moose and caribou populations. Although these studies are informative, their applicability to wolves and deer in Michigan is uncertain. Differences in prey densities among species, population dynamics, and predator responses make direct comparison difficult.

In Alaska, Valkenburg et al. (2004) investigated the effects of wolf control on caribou calf survival in the Delta herd and found that wolf control did not increase caribou calf survival. Though the fall 1993 wolf population in this area was reduced 60-62%, summer 1995-1997 wolf-caused calf mortality was 25%. Probable factors contributing to this failure included predation of calves by other predator species and too few wolves removed to be effective (Valkenburg et al. 2004). Strychnine has been used in Alberta to reduce wolf abundance to reduce predation of endangered caribou (Hervieux et al. 2014); 225 wolves were killed from 2005-2018. The wolf population control program appeared to stabilize the caribou population but did not result in a population increase (Hervieux et al. 2014).

Only one study has examined wolf control in an area where white-tailed deer are the primary prey. Potvin et al. (1992) evaluated the effect of reducing wolves in a reserve in Quebec on deer numbers, fawn survival and buck harvest. Similar to other wolf-control programs, wolf removal was conducted by aerial shooting. Because of heavy forest cover, wolves were captured and radio-collared during the summer to aid in locating packs during the winter control operations. The results of this study were at least partially confounded by a series of mild winters that allowed deer numbers to increase in the area where no wolf control was applied. Despite this problem, in the area where wolf numbers were reduced by an average of 71% for 3 years, the deer population increased at a rate 15% higher than in the area where no wolf control was applied. This increase in deer numbers did not result in a measurable increase in buck harvest.

Attitudes of Michigan Residents

The following section discusses relevant findings from the 2021 public-attitude study (Riley et al. 2022) that surveyed a sample of more than 15,000 Michigan residents as well as survey of licensed deer hunters. Details of the study methods and additional results are presented elsewhere in this document (i.e., Chapter 2) .

Role of Wolves

The 2021 survey evaluated the importance of 10 possible reasons for valuing having wolves in Michigan. One of the proposed reasons was that wolves are an important part of ecosystems. About 70.2% of the general public strongly or moderately agreed that wolves are an important part of ecosystems, with differences reported across regions. UP residents were less likely to agree with this statement (51.9% strongly or moderately agreeing), and SLP residents were mostly likely (75.3% strongly or moderately agreeing).

In comparison, deer hunters expressed less agreement with this statement than the general public, with 46.5% indicating they strongly or moderately agree that wolves are an important part of ecosystems. Deer hunters received an additional subset of questions to help understand perceptions of the relationship between white-tailed deer populations and wolves. Deer hunters provided mixed responses regarding the competition between hunters and wolves for deer and the role of wolves in maintaining healthy populations of deer. While 21.43% strongly agreed that wolves are an important part of the Michigan environment, 19.81% strongly disagreed. 24.6% of hunters either moderately or strongly agreed that wolves help maintain healthy deer populations, 30.9% strongly or moderately disagreed. 35.5% of deer hunters strongly or moderately agreed that wolves compete too much with Michigan hunters for deer, whereas 21.5% strongly disagreed that wolves and hunters compete too much. Overall, more deer hunters strongly or moderately agreed that it is important to maintain a wolf population in Michigan (46.0%) than strongly or moderately disagreed (22.05%), and while 16.3% strongly agreed that they would be happier if there were no wolves in Michigan at all, 37.5% strongly disagreed with that statement.

Perceived Risk to the Deer Population

Compared to the general public, deer hunters indicated that wolves are a higher risk to the populations of white-tailed deer, with 77.3% indicating wolves present a large or moderate risk. In comparison, 66.9% of the general public indicated wolves present a large or moderate risk to those deer. However, differences were reported across regions in the general public survey. UP residents assess risk even more seriously than deer hunters, with 83.5% indicating wolves present a large or moderate risk to populations of white-tailed deer.

Chapter 7 Wolf Harvest as a Recreational Opportunity

Executive Summary

Recreational harvest of wolves is a controversial issue that often polarizes stakeholder groups. It is also biologically complex; the amount of harvest a wolf population can sustain is determined by many factors. However, there is adequate knowledge of wolf biology and ecology to sustainably harvest wolf populations.

Research indicates an average wolf population could be expected to stabilize when annual wolf mortality (excluding pups) reaches approximately 22-28%. However, the levels of mortality which populations can endure are highly variable, and are influenced by population size, age and sex structure, immigration and emigration rates, and birth rates. Moreover, wolf mortality is often compensatory, meaning human-induced mortality can sometimes replace mortality that would otherwise occur due to natural factors, such as starvation, disease or intraspecific aggression.

Public wolf harvests have recently occurred in Canada, Alaska and areas of Europe and Asia. In these areas, hunters and trappers annually removed as much as 28% of the wolves in an area, but the populations appeared to remain stable or to increase. However, comparisons between wolf harvests in other areas and a potential public wolf harvest in Michigan are problematic. Differences in the number of people, access, and habitat conditions limit the utility of such comparisons.

Less than half (38.5%) of respondents to the 2021 public-attitude survey disagreed that potential game status of wolves was a reason to have wolves in Michigan. However, approximately half (49.2%) of respondents statewide indicated support for a legal, recreational hunting season for wolves, if biologists and the DNR believed the wolf population could sustain it, with 30.4% opposing. Respondents were more likely to oppose (42.6%) a trapping season than support it (36.0%). Approximately two-thirds (68.2%) of respondents statewide supported use of licensed hunters as a means of removing wolves from an area. Fewer indicated support for the use of trappers to remove wolves, slightly over half (58.2%). The greatest difference of opinion on a hunting or trapping season for wolves was between the general public survey and the surveys of deer hunters, fur harvesters, and livestock producers. A hunting season for wolves was supported by 83.6% of deer hunters statewide. Most deer hunters also supported a recreational trapping season for wolves (71.5%). Support for both a trapping and hunting season was greatest among fur harvesters, with 95.8% supporting a recreational hunting season and 91.3% supporting a recreational trapping season. Responses for UP livestock owners were similar to deer hunters and fur trappers (85.6% supporting a hunting season and 81.1% supporting a trapping season).

Introduction

Recreational harvest of wolves is a controversial and contentious issue that often polarizes stakeholder groups interested in wolf conservation and management. In *Beyond Wolves*, Nie (2003; page 59) wrote: "The issue of hunting and trapping wolves—a public take—after they become delisted is perhaps the most divisive and potentially explosive issue in the entire wolf debate. It engenders the type of emotions and deep core values that make conflict resolution nearly impossible to achieve." Recreational harvest of wolves is also biologically complex (Mech 2001). The amount of harvest a specific wolf population can endure is determined by a suite of factors, including population size, age and sex structure, immigration and emigration rates, birth rates, and natural and human-induced mortality rates.

Wolf Biology and Harvest

Mortality Rates and Population Trends

The growth of any population, including wolves, is dependent on the interaction of the rates of reproduction, mortality, immigration and emigration. From a wolf-management perspective, the rate of mortality is the factor over which managers can exert the most control.

Wolves are prolific, with litters averaging 4–7 pups across much of their range (Mech 1970, Fuller et al. 2003, Ferreras-Colino et al. 2010). But wolf litter sizes can be greater based on wolf density, with lower density populations having larger litter sizes (Sidorovich et al. 2007). As a result, wolf populations can remain stable or increase despite relatively high mortality rates (Fuller 1989, Mech 2001, Adams et al. 2008, Creel and Rotella 2010).

Annual mortality tends to fluctuate from year to year and can be compensatory (Fuller et al. 2003, Mech 2001, O'Neil 2017). That is, human-induced mortality can sometimes replace mortality that would otherwise occur due to natural factors, such as starvation, disease or intraspecific aggression (Fuller et al. 2003). Natural mortality of eastern wolves near Algonquin National Park increased following cessation of legal human harvest (Rutledge et al. 2010). For example, Adams et al. (2008) analyzed North American wolf populations and found that wolf population trends were not associated with levels of human-caused mortality <29%, due primarily to local dispersal, emigration and immigration. In contrast, in a meta-analysis using data from 21 wolf populations in North America, Creel and Rotella (2010) suggested human offtake could be additive or result in super-additive increases in total wolf mortality. However, Creel and Rotella (2010) also concluded that wolves can be harvested sustainably within limits. In a reanalysis of these same data considering data limitations and improved modeling, Gude et al. (2012) determined that the predictions for declining wolf populations reported by Creel and Rotella (2010) were not supported. In Wisconsin, human-caused mortality likely needs to exceed 23-24% for the wolf population decline to occur (Stenglein 2014, Stenglein et al. 2018).

Studies in Minnesota and Denali National Park, Alaska, where wolves are not harvested, reported that approximately 10% of the wolves in each population were killed by other wolves (Mech 1977a, Mech et al. 1998). By contrast, in areas of Alaska where wolves were legally harvested, mortality due to intraspecific aggression was much lower (Peterson et al. 1984, Ballard et al. 1987, Ballard et al. 1997). This comparison supports the conclusion that mortality caused by other wolves can be compensatory to that caused by harvesting (Mech 2001). Wolves in and near Denali National Park, Alaska, did not experience short- or long-term changes in population dynamics, and at harvest levels experienced, were suspected to be resilient to this mortality source (Borg et al. 2015, 2017).

While excluding mortality of pups from birth through autumn, Fuller et al. (2003) estimated that, on average, a wolf population can be expected to stabilize when the total annual mortality rate is 0.34 ± 0.06 SE, or when the human-induced annual mortality rate is 0.22 ± 0.08 SE. However, the effects of human-induced mortality can vary substantially among populations (Gasaway et al. 1983, Peterson et al. 1984, Ballard et al. 1987, Fuller 1989, Lariviere et al. 2000, Hayes et al. 2003). In north-central Minnesota, a wolf population experiencing a human-induced mortality rate of 29 percent was found to be stable or increasing (Fuller 1989). In Alaska, a wolf population declined after harvests ranging from

42 to 61% but increased by 58% following a take of 32% (Peterson et al. 1984). In Quebec, a population remained stable while facing a sustained harvest of 74%; this population was apparently maintained by immigration (Lariviere et al. 2000). Several other studies have shown that wolf populations can sustain annual winter harvests of 28–47% without permanent declines in their numbers (Mech 1970, Ballard et al. 1987, Ballard et al.1997). Sources of variation include the age and sex structure of the population, the degree of compensation among mortality factors, reproductive status of harvested animals, time of mortality, and the rates of reproduction, immigration and emigration (Fuller 1989, Fuller et al. 2003, Adams et al. 2008, Borg et al. 2015). In addition, some variation is the result of measurement error and/or the analysis technique used.

Annual mortality rates of radio-collared wolves in the Upper Peninsula averaged between 0.13 and 0.32 from 1997 through 2012 (O'Neil et al. 2017). It is important to note that these mortality estimates may be, to an unknown degree, biased because captured wolves were vaccinated for a variety of diseases and treated for mange prior to 2004. This practice may have reduced the amount of natural mortality observed.

Additional Impacts

Although wolf populations are able to recover numerically from human-induced reductions, harvest may impact wolves in ways that are less obvious than changes in population size. Wayne (1996) indicated kinship ties affect social stability and pack persistence. Lehman et al. (1992) found, compared to two protected populations, a heavily harvested population exhibited fewer kinship ties and showed a more rapid rate of genetic turnover, similar to Rutledge et al. (2010) for eastern wolves. Rick et al. (2017) suggested that anthropogenic harvest in Minnesota has a non-negligible effect. Although Rick et al. (2017) found no differences in genetic heterozygosity and allelic richness, they noted population genetic structure increased and effective migration decreased among wolves sampled, and recommended additional studies to better understand the effects of harvest on population structure and gene flow (Rick et al. 2017). Harvest may also affect age structure of a wolf population. In Denali National Park, where the population is protected, wolves often live 7–10 years (Haber 1996). By contrast, wolves rarely live more than 5–7 years in harvested populations (Stephenson and Sexton 1974, Hayes et al. 1991). Few wolves harvested during the 2012 and 2013 Minnesota wolf harvest seasons were >6 years old (Stark and Erb 2013, 2014).

Loss or removal of wolves, however can influence later short-term reproductive success. Brainerd et al. (2010) found that the wolf packs where one breeding member needed to be replaced were more likely to reproduce the following season than packs where both breeders needed to be replaced. But at the population level, wolves in and near Denali National Park, Alaska, did not experience short- or long-term changes in population dynamics from harvest levels of wolves near the park; wolves were suspected to be resilient to this mortality source (Borg et al. 2015, 2017). Bassing et al. (2019) found wolf pack abundance and distribution remained stable during harvest, suggesting that environmental factors had a greater influence than harvest, but that harvest appeared to strongly influence turnover of individuals within packs.

Historic & Current Wolf Harvests

Prior to the 1970s, wolves in North America were hunted and trapped with few restrictions. Throughout much of their histories, Native Americans have hunted and trapped wolves over most of the continent

(Nelson 1983). Some authors believe aboriginal peoples hunted wolves as a way to enhance ungulate populations (Berkes 1999). Following European settlement, year-round seasons and non-existent bag limits were typical in both Canada and the United States. Few provinces, territories or states required registration of wolf pelts, and numbers harvested were roughly estimated at best. Where recreational harvest figures are available, they typically do not include those animals taken by subsistence hunters in Alaska or First Nation members (indigenous peoples) in Canada.

Since the 1970s, when wolves became legally protected in the lower 48 States, legal recreational harvest of wolves in North America has generally been restricted to Alaska and most provinces of Canada (Hayes and Gunson 1995, Musiani and Paquet 2004). However, when wolves were removed from listing under the Endangered Species Act, legal harvests occurred in Minnesota, Wisconsin, and Michigan during the period 2012-2014. Further, following federal delisting in 2021, Wisconsin held legal wolf harvest in February 2022. Legal recreational harvest also occurs in several Western Europe and Eurasian countries. The following text summarizes regulations, levels of take, and population impacts associated with recent recreational harvests of wolves in various parts of the world.

Canada

Throughout Canada, First Nations members may hunt and trap wolves without restriction. Other residents require licenses for hunting and trapping according to regulations set by individual provinces and territories. Resident hunters in the Northwest Territories may take wolves under a general resident license, whereas resident hunters in Yukon, British Columbia and Manitoba may take wolves under big game licenses, and resident hunters in Labrador, Quebec, and Ontario may take wolves under small game licenses. Ontario resident hunters are required to have an additional wolf tag to hunt in specific areas. Resident hunters in Saskatchewan may take wolves under a specific wolf license, and Alberta residents do not need a license to take wolves. Most Canadian provinces and territories do not charge special fees or require hunting tags or seals for wolves. In general, wolf trapping is allowed in Canadian provinces and territories under a trapping license. Where harvest is allowed, wolves may be taken by foot-hold traps, snares or shooting.

Statistics on wolf hunting are not compiled throughout much of Canada. Better data are available for trapping harvest levels. Yukon requires pelt sealing for commercial sale. In other areas, trapping harvest is tracked using records from auction sales or trapper questionnaires.

In 1995, Hayes and Gunson (1995) reported hunters and trappers took approximately 4,000 wolves annually, representing an estimated 4–11 percent of the population. In most areas, trappers took more wolves than did hunters. Between 1983 and 1990, however, the number of wolves taken by trappers declined by 40 percent (Hayes and Gunson 1995).

In 1995, wolf population size in Canada was estimated to be 52,000–60,000 wolves (Hayes and Gunson 1995). Changes in local wolf densities appeared to be influenced primarily by prey availability (Hayes and Gunson 1995). Theberge (1991) indicated that, outside of extreme southern Canada where large human populations occurred and harvest effort was concentrated, recreational harvest did not appear to be limiting the wolf population. In the ten territories or provinces where the wolf was classified as a game species, six of the populations were considered stable whereas four were considered increasing in the year 2000 (Boitani 2003). During 1994-2004, an average of 2,450 pelts were sold in Canada, representing typically less than 10% of the total population each year (Government of Canada 2014).

Based on annual birth rates for wolves, the annual harvest in Canada is considered sustainable (Government of Canada 2014). In 2010, the wolf population in each of the 10 Canadian territories or provinces where wolves occur and are harvested was considered secure (Government of Canada 2014). The sustainable harvest of wolves remains legal throughout most of Canada (e.g., Government of British Columbia 2020, Alberta Government 2021, Province of Ontario 2022).

Alaska

In Alaska, permissible wolf-harvest methods have fluctuated since the 1970s (Alaska Department of Fish and Game 2005). Previously, wolves were taken by recreational trappers during trapping seasons which averages 6 months, with no bag limit. Snaring is allowed and is often the method preferred by trappers in many parts of Alaska (Scott and Kephart 2002). Wolves may be taken as trophy animals and are often harvested incidentally by hunters pursuing other species, such as moose and caribou. The harvest season for wolves was up to 6 months (1 November to 30 April) with no limit. The State of Alaska has since liberalized hunting methods, particularly for those management units selected for wolf control. Use of snowmobiles are currently allowed, and land-and-shoot hunts have been previously allowed in some areas. Aerial gunning and land-and-shoot hunts are used specifically in areas where the goal is to reduce wolf population size as part of Alaska's predation control program but are considered wolf control and not a form of hunting or trapping.

Hunters and trappers typically take about 1,200 wolves per year during 1999-2020 (Alaska Department of Fish and Game; unpublished data) and in the most recent reporting year (July 2020-June 2021), with 1,168 individuals sealed, wolves ranked as the third most important furbearing species in Alaska (Bogle 2021). This level of take, which is low relative to the maximum legal harvest, may be due to the limited road access and extreme winter conditions throughout much of Alaska during the wolf season. At the current level, an estimated 17–28 percent of the population is harvested annually. In 2000, the wolf population, which consisted of 6,000–7,000 animals, was considered to be stable or increasing (Boitani 2003). Currently, the Alaska Department of Fish and Game estimates 7,000-11,000 wolves statewide (Alaska Department of Fish and Game 2022).

Great Lakes States

Minnesota has the largest wolf population of the Great Lakes states, estimated at approximately 2,700 wolves in 2019–2020 (Erb and Humpal 2020). Minnesota held hunting and trapping seasons during 2012–2014 following federal delisting in 2011. The total harvest of wolves during those years was 413 in 2012, 238 in 2013, and 272 in 2014. Following the most-recent wolf delisting in 2021, officials in Minnesota delayed official consideration of a public harvest until after the state's wolf management plan is updated. Wisconsin has an estimated wolf population of 1,195 wolves (Wiedenhoeft et al. 2020). Wisconsin also held wolf hunting and trapping seasons during 2012-2014, with a total wolf harvest of 117 in 2012, 257 in 2013, and 154 in 2014. Following wolf delisting in 2021, Wisconsin held an additional hunting and trapping season during February of 2021 that resulted in the harvest of 218 wolves. A wolf hunting season in Wisconsin is required by statute when wolves are not federally listed as threatened or endangered. During periods when hunting is allowed, hunters in Wisconsin can pursue wolves with the aid of calls, bait, traps, and dogs. Michigan held a single hunt from November 16th to December 31st, 2013 in three areas of the Upper Peninsula; 23 wolves were harvested.

Western States

The wolf population in western states was 3,500 or more in 2020. Harvest management has varied across these states over the past two decades. For example, the Montana Wolf Management Advisory Council through Montana's Wolf Conservation and Management Plan (2000) offered the following guiding principle with regard to recreational harvest: "Opportunities for regulated public take of wolves through hunting and trapping should be provided as wolf numbers increase, but opportunity should also be consistent with sustaining viable wolf populations into the future, thereby precluding reclassification under Federal law." Accordingly, the Montana Fish, Wildlife and Parks Department provides opportunities for a regulated wolf harvest following Federal delisting of the species. In Montana, the wolf population was about 1,400 individuals in 2011. From 2012-2019, 242 wolves were harvested annually on average, with 327 wolves harvested in the 2020 season (Inman et al. 2020). During the most recent (4 September 2021-15 March 2022) wolf hunting and trapping season in Montana, 273 wolves were harvested. The wolf population has been stable from 2011-2020 at about 1,100 individuals (Inman et al. 2020).

The Idaho Wolf Conservation and Management Plan (Idaho Legislative Wolf Oversight Committee 2002) included provisions for a regulated public harvest when the number of wolf packs exceeds a certain level. Hunting quotas were initially established to manage distribution of wolf harvests through 2016, after which harvest quotas were removed statewide (Idaho Fish and Game 2022). In 2009, 181 wolves were harvested in Idaho and harvests then declined from 377 in 2011 to 249 in 2014 (Ausband 2016), then to 226 wolves in 2016 (Hayden 2017). During the 2019-2020 season, 570 wolves were harvested. The Idaho Game and Fish Commission in 2021 expanded wolf seasons and methods of take to reportedly reduce wolf conflicts with livestock and elk (Idaho Fish and Game 2022). The 2021-2022 wolf hunting and trapping season was year-round (1 July-30 June) with no daily or season limit (Idaho Fish and Game 2021). Currently, about 1,543 wolves occur in Idaho and the population has been stable since 2019 (Idaho Fish and Game 2022).

Under the current Wyoming Gray Wolf Management Plan (Wyoming Game and Fish Department 2003), wolves are to be classified as either trophy game animals (regulated harvest) or predatory animals (unregulated harvest), depending on population levels and region of the State. Harvests in Wyoming are considerably less than harvests in Montana and Idaho, with 42 wolves harvested in 2012, 24 in 2013, 44 in 2017, and 33 in 2020 (Wyoming Game and Fish Department 2022). In 2020, the Wyoming wolf hunting season was year-round with a limit of 1 wolf per license during each calendar year and individuals were able to purchase 2 licenses each calendar year (Wyoming Game and Fish Commission 2020).

Other western states with wolves have had either limited jurisdiction to consider public harvest within the state (e.g., Utah), do not have a resident wolf population such that few wolves have been harvested (e.g., South Dakota), or had small wolf populations and did not authorize a harvest season (e.g., Oregon, Washington).

Spain, Poland and Russia

The wolf population in Spain included approximately 2,000 animals in the year 2000 (Boitani 2003) and is apparently stable, with about 2,500 individuals in the Iberian region population (Boitani 2018) of which about 80% occurs in Spain (Ordiz et al. 2022), Wolves in Spain were classified as a game species north of the Douro River but recent national listing has resulted in a discontinuation of recreational harvests (Ordiz et al. 2022). Previous harvests found the average annual limit was 19% of the population (Blanco et al. 1992). At this level of legal take, plus poaching, the population reportedly continued to expand into new areas and was considered stable or increasing in 2000 (Boitani 2003).

Until recently, wolves in Poland were classified as a game species. With an estimated population of 900 wolves, the annual bag limit was approximately 110 wolves, or 12% of the population (Bobeck et al. 1993). With this level of take, the population continued to expand. Today, wolves in Poland are officially protected with an estimated population of about 3,000 individuals.

The Russian wolf population does not receive any legal protection and was estimated to include approximately 25,000–30,000 animals. Despite the complete lack of regulation, the population was considered to be stable or increasing in 2000 (Boitani 2003). Indeed, more recent estimates since the year 2000 suggest the wolf population has ranged from about 45,000-55,000 individuals (Baskin 2016). Annual reported wolf harvests ranging from about 5,000 to 12,000 individuals, with long-term patterns in harvest associated with famine and social turbulence (Baskin 2016). Similar to the situation in Alaska, limited road access and winter conditions also likely prevents higher levels of annual harvest.

The overall effects of poaching on wolf populations is difficult to quantify. Poaching can be an important source of morality for wolves (e.g., Finland; Suutarinen and Kojola 2017) and has been reported to reduce wolf population growth (Liberg et al. 2012). In an analyses of 21 studies that monitored the fates of 3,564 wolves with 1442 reported mortalities, 23% of mortalities were from illegal harvest and 16% from legal harvest (Hill et al. 2022). Santiago-Avila et al. (2020) reported increased prevalence of unreported poaching of wolves in Wisconsin during periods of policy change providing increased ability to use lethal wolf control in defense of human property or safety. Treves et al. (2021) reported increases in undocumented poaching coincided with a legal wolf hunt in Wisconsin. However, it is not possible to quantify poaching that is not reported or otherwise documented. Documented poaching of wolves in Wisconsin reportedly increased during periods of snow cover and dog training and hunting seasons for other large mammals relative to the period 15 April-30 June (Santiago-Aviala and Treves 2022).

Relevance to Michigan

Harvests currently occurring elsewhere in North America seem most relevant when considering a public take in Michigan. However, comparisons between wolf harvests in Alaska, Canada, Idaho, Montana, Wyoming and Wisconsin and a potential harvest in Michigan are problematic. Most areas in Alaska and Canada have fewer roads, less access, and far fewer hunters and trappers interested in harvesting wolves. States in the lower 48 have numeric population goals and their harvest system are designed to lower their wolf populations to or near the state goal. With better access and other conditions, hunter and trapper success rates in Michigan could be higher than Western States, Alaska or Canada. However, many areas of Alaska and western Canada consist of vast open expanses, which make wolves vulnerable to hunters. In Michigan, most wolf habitat consists of dense forests, which provide defense against shooting and could help wolves elude hunters. The only legal harvest of wolves in Michigan in recent years occurred in 2013. Michigan's strategy was the most conservative hunt for wolves of any of the six states that allowed wolf hunting in the lower 48 states at the time. Both Minnesota and Wisconsin harvested wolves in 2013 however, their goals for their hunt and season structure were much different than ours. As an illustration, Minnesota issued 3,300 licenses and harvested 237 (goal 220) wolves. In

Wisconsin 2,510 licenses were issued to harvest 257 (goal 251) wolves. In Michigan 1,200 licenses were issued to harvest 22 (goal 43) wolves. Michigan was the only state which held a harvest season which was designed around resolving conflicts. The harvest recommendation of 43 wolves distributed among the three areas was designed to reduce conflicts in two ways. First many studies have shown that hunting can change the behavior of wildlife, often increasing wariness (e.g., Bender et al. 1999, Croes et al. 2006). If wolves avoid humans, conflicts may decline. In some areas, increases in livestock depredations have been associated with increasing predator abundance (Robel et al. 1981, Nass et al. 1984, Yom-Tov et al. 1995). Secondly, the harvest may reduce the number of wolves in these areas, which in turn might reduce the number of conflicts (Baker et al. 2008). However, because wolves were returned to the Federal List of Endangered Species no other harvest of wolves has occurred in Michigan to date. Currently, wolves are listed as a protected game animal in Michigan.

The legal status of wolves in the Great Lakes region at the Federal level has changed multiple times since March 2007, when wolves were removed from the Federal List of Threatened and Endangered Species, only to be placed back on the list in September 2008. A second attempt to delist wolves became effective in May 2009, however wolves were formally returned to the List by September 2009. In January 2012, wolves were once again federally delisted which lasted until December 2014 when a federal court vacated the U.S. Fish and Wildlife Service's delisting. The latest attempt to federally delist wolves became effective in January 2021, but this attempted was also vacated by a U.S. District judge returning wolves to the Endangered Species List in February 2022.

In Michigan, wolves were removed from the State Threatened and Endangered Species List (Part 365 of Public Act 451 of 1994) in April 2009 and given Protected Animal status under the State's Wildlife Conservation Order. In the fall of 2013, when wolves were federally delisted, Michigan held its first public harvest of wolves as a management tool to resolve chronic negative wolf-human interactions. The laws which reclassified wolves as a game species in Michigan were repealed by voter referendum in November 2014. However, in August 2014 prior to the public vote, citizen-initiated legislation (Public Act 281) classified wolves as game animals. Public Act 281 added the authority to classify species as game animals to the NRC's already existing authority to decide if a game species will be hunted, and the parameters around a regulated harvest. An organization (Keep Michigan Wolves Protected) challenged the constitutionality of Public Act 281 however the Michigan Court of Claims dismissed the lawsuit in July 2015. Then in November 2016, an appellate court overturned the 2015 Michigan Court of Claims ruling removing the NRC's authority to classify gray wolves as a game species. Nine days after the appellate court ruling a Senate Bill was introduced which once again granted authority to the NRC reclassify wolves in Michigan as a game species when it was signed into law in December 2016 (Public Act 382).

Wolves are currently listed as game animal in Michigan however, they were once again placed back on the Federal Endangered Species List on February 10, 2022. If wolves are federally delisted the Michigan DNR believes that before a wolf hunt should be considered, several things should take place: 1.) The legal status of wolves should be more permanently settled, especially given the long history of legal challenges to delisting decisions and the resulting shifting status of wolves, 2.) The DNR's wolf management plan should be updated upon completion of a public attitude study in 2022, and 3.) The DNR should consult with the federally recognized tribal governments located in Michigan prior to developing any potential hunt.

Attitudes of Michigan Residents

This section discusses relevant findings from the 2021 public-attitude study (Riley et al. 2022) that surveyed a sample of more than 15,000 Michigan residents. Details of the study methods and additional results are presented elsewhere in this document (i.e., Chapter 2).

Acceptability of legal, recreational hunting and trapping seasons for wolves

Approximately half (49.2%) of respondents to the 2021 public-attitude survey statewide indicated support for a legal, recreational hunting season for wolves, if biologists and the DNR believed the wolf population could sustain it, with 30.4% opposing. Support is higher in the UP, with an estimated 67.2% of UP respondents supporting a hunting season for wolves, while 20.7% oppose a season and 12.1% are undecided. Considerably less than half (38.5%) of respondents disagreed that potential game status of wolves was a reason to have wolves in Michigan.

The most frequent (59.0%) reason given for the acceptability of a hunting season was support for hunting as a mechanism to control wildlife populations including wolves. Concern about sustainability of hunting was an important criterion, as was concern that if hunted, wolves would become endangered again. Nearly 44% of the population is estimated to oppose hunting of wolves when the motivation is recreation. Only 3.8% of people are estimated to oppose hunting for any species of wildlife.

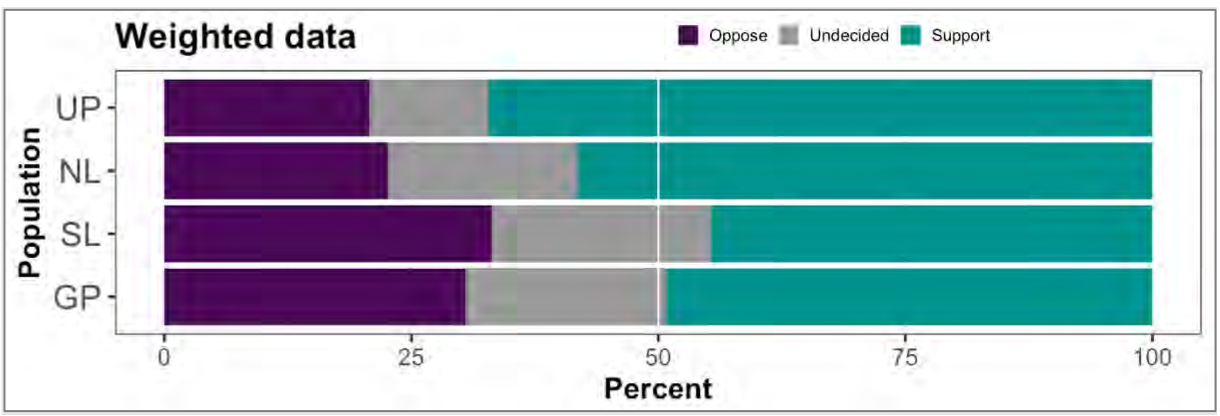

Figure 7-1 If biologists and the DNR believe the wolf population could safely sustain a hunting season, which of the following best describes your opinion about a legal, recreational wolf hunting season in Michigan?

Patterns associated with trapping mirrored those for hunting except in every case there was less support for trapping than hunting. Respondents were more likely to oppose (42.6%) a trapping season for wolves than support it (36.0%). Likely, the issue of trapping wolves is intertwined with value orientations about trapping in general. More than 24% do not support trapping for any species of wildlife. However, support was greatest among UP respondents, with 57.1% supporting a trapping season for wolves.

Similar to patterns associated with reasons for acceptability of a hunting season, the most frequent (38.7%) reason given for the acceptability of a trapping season was support for hunting as a mechanism to control wildlife populations including wolves. Concern about sustainability of trapping was an important criterion, as was concern that if trapped, wolves would become endangered again. Nearly 44% of the population is estimated to oppose trapping of wolves when the motivation is recreation. Far more respondents do not support trapping of any species of wildlife, in contrast with support for hunting, with 24.3% opposing trapping for any species of wildlife.

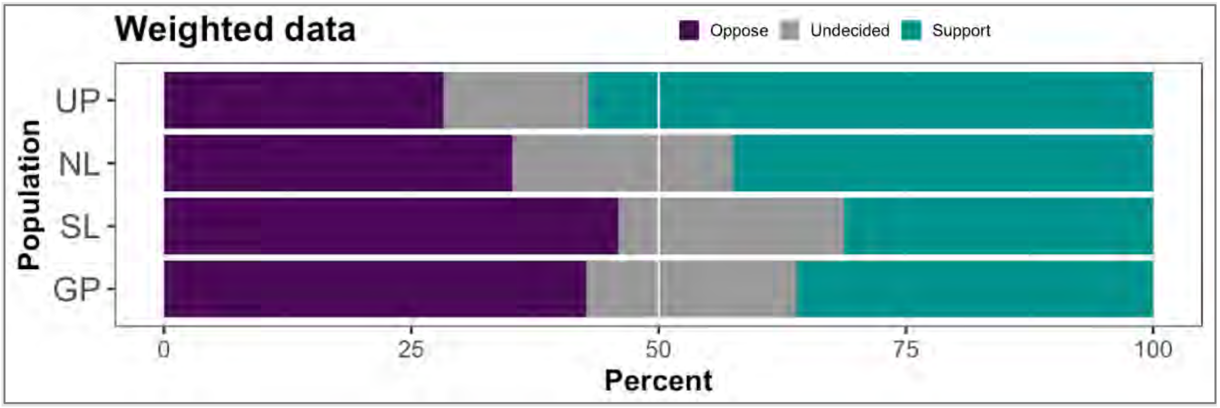

Figure 7-2 . If biologists and the DNR believe the wolf population could safely sustain a trapping season, which of the following best describes your opinion about a legal, recreational wolf hunting season in Michigan?

The greatest difference of opinion on a hunting or trapping season for wolves was between the general public survey and the surveys of deer hunters, fur harvesters, and livestock producers. A hunting season for wolves was supported by 83.6% of deer hunters statewide. Most deer hunters also supported a recreational trapping season for wolves (71.5%). Support for both a trapping and hunting season was greatest among fur harvesters, with 95.8% supporting a recreational hunting season and 91.3% supporting a recreational trapping season. Responses for UP livestock owners were similar to deer hunters and fur trappers (85.6% supporting a hunting season and 81.1% supporting a trapping season).

The 2005 survey also explored respondent attitudes about a harvest of wolves for recreational purposes even when control of the population was not needed. Respondents were asked whether they agreed with creating a hunting or trapping season for wolves only to provide recreational benefits, assuming it could be done without endangering the wolf population. Half of the interested citizens statewide agreed that a legal, controlled hunting season should be created if the wolf population could support it; about one-third of respondents disagreed (12% 'somewhat disagreed' and 21% 'strongly disagreed'). Statewide, citizens were more polarized on the question of a trapping season: 48% of respondents agreed and 41% of respondents disagreed that a legal, controlled trapping season should be created if the wolf population could support it. Although comparisons of the 2021 and 2005 should be taken with caution due to different methodologies, results suggest that while support has stayed relatively constant for a hunting season for wolves, around 50%, support for a trapping season has declined over time.

Use of hunting and trapping to remove wolves

If one or more wolves had to be removed from an area for some reason, the most acceptable method among four choices was "provide a limited number of permits to licensed hunters to shoot wolves during a controlled hunt" (68.3%). These results are similar to the results of the 2005 attitudes survey which found that approximately two-thirds of respondents statewide supported the use of licensed hunters as a means of controlling wolf populations. In the 2021 survey, this method of removal was least favored in the SLP and most favored in the UP. Fewer indicated support for the use of trappers to remove wolves, slightly over half (58.2%). The least acceptable means of removal was to “kill wolves that are trapped by trained, paid professionals” state-wide and among all regions.

Chapter 8 Habitat Linkages and Corridors

Executive Summary

Migration and gene flow are important for the long-term persistence of wolves in Michigan and the Great Lakes region, and state natural resource agency wolf plans should identify the need to ensure adequate habitat linkages and dispersal corridors among jurisdictions. Wolves are capable of dispersing long distances: movements between the Upper Peninsula and Wisconsin, Minnesota and Ontario have been documented multiple times since wolves became re-established in Michigan. Wolves are capable of crossing many potential barriers including highways, agricultural lands, rivers, and frozen lakes. A series of linear obstacles, however, may be more likely to hinder wolf movements. Analysis of land-use in Michigan, Wisconsin, and Minnesota has indicated sufficient habitat will be available to support a viable wolf population into the future (van den Bosch et al. in prep.). The amount and configuration of public wild lands in Michigan, Wisconsin, Minnesota and Ontario suggests habitat linkages can be effectively conserved.

Habitat Linkages and Corridors

Wolf recovery in the Upper Peninsula began with immigration of wolves from Minnesota, Wisconsin and Ontario (Thiel 1988, Mech et al. 1995). Migration and gene flow among these jurisdictions help preserve or enhance genetic diversity within populations and helps mitigate the effects of detrimental demographic fluctuations due to environmental catastrophes (Simberloff and Cox 1987, Boitani 2000). Therefore, continued movement of wolves within and among these jurisdictions is important for the long-term viability of the wolf population (e.g., Beyer et al. 2006).

The wolf-management plans in Michigan (Michigan DNR 2015) and Wisconsin (Wisconsin DNR 1999) identify the need to cooperatively plan and manage habitat linkages to ensure continued wolf movements among the Great Lakes states. However, neither plan provides specific guidelines for maintaining linkages. The Minnesota plan (Minnesota DNR 2001) indicates there is currently no barrier to wolf dispersal between Minnesota and Wisconsin or Ontario and does not identify a need to protect wolf dispersal corridors between Minnesota and Wisconsin in the future.

Wolves are effective dispersers (Forbes and Boyd 1997, Boyd and Pletscher 1999, Jiminez et al. 2017, Moralez-González et al. 2022). Adequate linkages currently appear to exist among Michigan (Upper Peninsula), Wisconsin and Minnesota (van den Bosch et al. in review): since the early 1990s, movements of numerous wolves between the Upper Peninsula and either Minnesota or Wisconsin have been documented (Mech et al. 1995, Michigan DNR, unpublished data). There is also evidence of wolves moving between the eastern Upper Peninsula and Ontario across Whitefish Bay and the St. Mary’s River (Jensen et al. 1986, Thiel and Hammill 1988, Michigan DNR, unpublished data).

The types of landscape features that represent barriers to wolf movements are poorly understood. Long-distance movements of wolves through human-dominated landscapes in Minnesota and Wisconsin suggest highways and roads are not full barriers (Mech et al. 1995, Merrill and Mech 2000). However, wolf survival declines overall with longer-distance dispersals (Moralez-González et al. 2022). In Spain, wolves regularly crossed a fenced four-lane highway on bridges over the highway (Blanco et al. 2005). Wolves are also capable of traveling through crop and range land (Licht and Fritts 1994, Wydeven et al. 1998). Wolves can cross ice-covered lakes and rivers (Mech 1966, Orning et al. 2020) as well as unfrozen rivers during the summer (Van Camp and Gluckie 1979). However, a series of linear obstacles, such as a river flanked by roads, railways and disturbed habitat, may act synergistically and be more of a barrier to wolf movement (Blanco et al. 2005). Further, areas of greater human activities can also limit wolf movements and dispersal (Moralez-González et. al. 2022, van den Bosch et al. in review). Jensen et al. (1986) suggested human settlement along the St. Mary's River was a barrier to dispersing wolves, but some wolves have been able to obtain passage, apparently by avoiding urban areas (Mech et al. 1995).

Wolf habitat within current range in Michigan, Wisconsin, and Minnesota is largely continuous, with few barriers to limit wolf movements and dispersal (van den Bosch et al. in review). More broadly, connectivity between the wolf population in Michigan, Wisconsin, and Minnesota and other areas of suitable habitat in the eastern United States appears limited by extensive agriculture, high human populations and the Great Lakes (van den Bosch et al. in review).

An earlier University of Michigan study evaluated whether there would be sufficient range to support a viable wolf population in Michigan and Wisconsin in 2020 (Hearne et al. 2003). This assessment focused on several factors, including land ownership and stability of protection, rates of land-use conversion, and changes in human and road density. The results of this study suggest the amount of suitable wolf habitat expected to be available in 2020 would be sufficient to maintain a viable wolf population. A more recent study evaluated the effects of forecasted climate and land use change on habitat for wolves in Michigan, Wisconsin, and Minnesota (van den Bosch et al. in prep.). These authors found that wolf habitat would largely be unaffected, suggesting suitable habitat to support wolves would remain through the year 2100.

Further, land owned by Federal, State, Provincial, or local units of government receive more-stable level of protection than does privately-owned land. The amount and distribution of government-controlled wild lands in Minnesota, Wisconsin, Michigan and Ontario (Figure 8-1) suggest habitat linkages in the region can be effectively conserved. However, we note that the suitability of areas for large carnivore recolonization depends not only on its environmental conditions, but also human willingness to co-exist with them (Treves and Karanth, 2003; Gompper et al, 2015), as recolonization can be limited by human persecution (Mech et al., 2019, Recio et al., 2020).

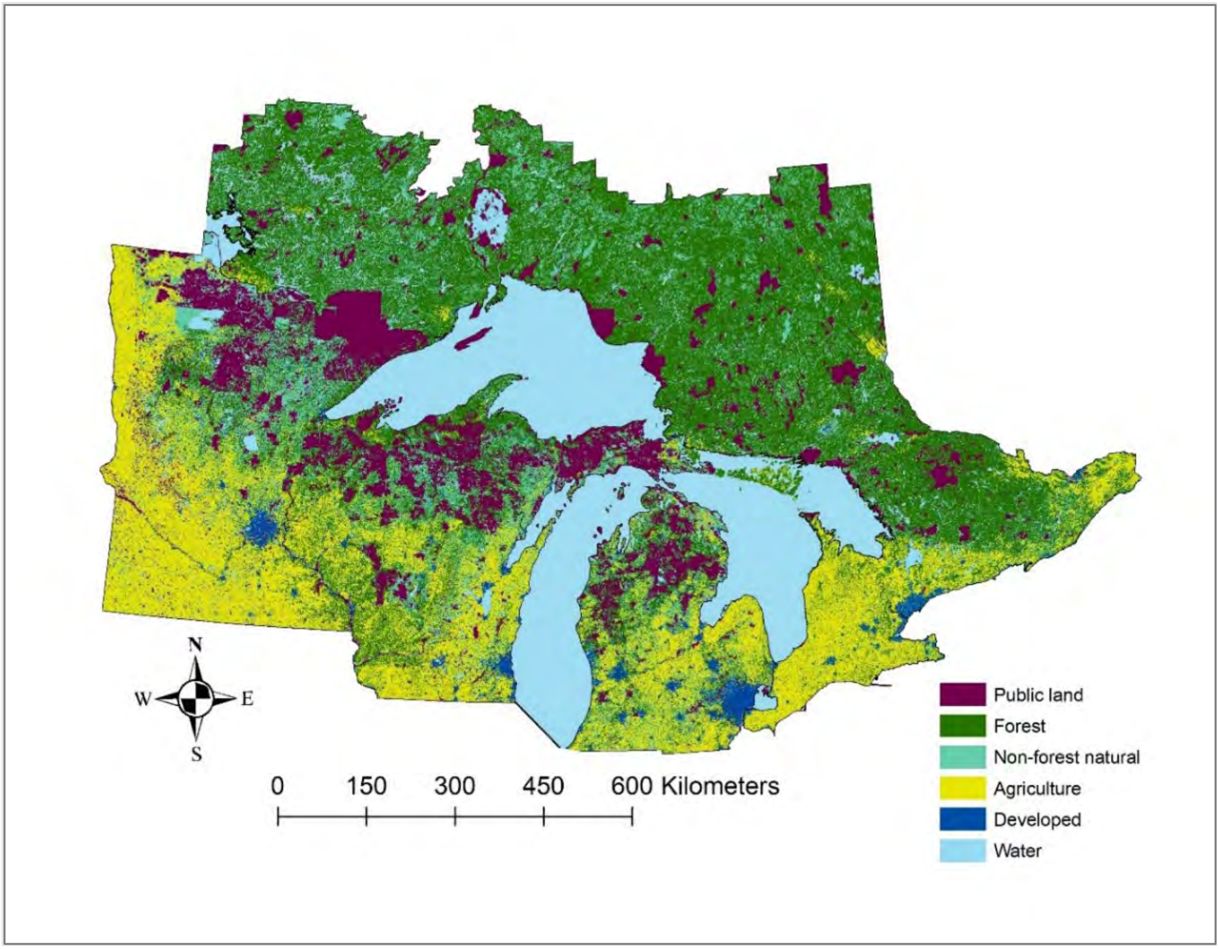

Figure 8-1 Distribution of government-managed public lands (shaded purple) in Michigan, Wisconsin, Minnesota, USA and southern Ontario, Canada.

Chapter 9 Information & Education

Executive Summary

Much attention has been given to wolves in recent decades through a variety of media. However, public knowledge of wolves in Michigan remains somewhat poor. Researchers, managers, and stakeholder groups generally agree an informed public is important for effective wolf conservation and management. The current Michigan wolf plan identifies education as a high priority.

Wolves tend to produce strong opinions among members of the public. Those opinions are often based on core values which are resistant to change. The predisposition of people to accept or reject information based on pre-conceived notions and values presents challenges for a wolf education program. Another challenge is to present information that is not biased toward a particular point of view. A third challenge involves the focus on controversy and extreme opinions characteristic of many popular media reports: the public may receive inaccurate or exaggerated impressions of the extent of wolf-related conflicts. These challenges may be mitigated or overcome by (1) targeting individuals who do not already hold strong opinions about wolves, (2) developing education materials in partnership with organizations trusted by certain stakeholders, and (3) working with the media to foster the presentation of accurate information to large audiences.

The Michigan DNR conducts a number of wolf education and outreach activities including presentations to stakeholder groups, responses to public inquires, brochures with information on ways to reduce wolf–livestock and wolf–human conflicts, provision of wolf information on its website, and display of interpretive signs.

Introduction

During recent decades, much attention has been given to wolves through a variety of media (e.g., Black and Rutberg 2007, Chandelier et al. 2018, Arbieu et al. 2019, Killion et al. 2019). Publication of wolf-related research in scientific literature became increasingly common (Fritts et al. 2003). The reintroduction of wolves to Yellowstone National Park in the 1990s was preceded and followed by extensive public education (Fritts et al. 1995). Conservation organizations, such as Timber Wolf Alliance, have focused on educating the public about wolves. Centers dedicated to wolf education, such as the International Wolf Center in Ely, Minnesota, have become popular attractions. In 1990, the International Wolf Center began publishing *International Wolf* magazine. In addition, numerous websites, books, documentaries, magazines and other media reports have provided the public with information on wolves.

Increasing exposure to popular information, much of it portraying wolves favorably, has contributed to positive public attitudes which helped foster recovery of the species. Despite the great availability of wolf-related material, however, the general public still holds many misconceptions about wolves. Mertig (2004) found that Michigan-resident knowledge of wolves was generally poor, noting that public understanding had not improved significantly during the 12-year period following re-establishment of the wolf population in the Upper Peninsula.

Researchers, managers, and stakeholder groups generally agree an informed public is important for wolf conservation and management (e.g., Fritts et al. 2003, Kuhl 2019, Straka et al. 2020; see also Decker et al. 2016). Indeed, almost 50 years ago, the IUCN Manifesto on Wolf Conservation (Pimlott 1975) recommended the development of wolf education programs to help promote wolf conservation. State and federal wolf plans (e.g., U.S. Fish and Wildlife Service 1992, Wisconsin DNR 1999, Minnesota DNR 2001) frequently identify education and outreach as important components of recovery and management programs. Previous and current Michigan wolf management plans (Michigan DNR 1997, 2008, 2015) also identify education as a high priority.

Challenges of Education as a Means for Managing Wolf Issues

The need for education is widely recognized, but development of an effective education program can be difficult. Strong public opinions and the controversial nature of many wolf-related issues present educators with several challenges.

Influence of Knowledge versus Values

Education is often expected to persuade stakeholders to modify their attitudes or to change certain behaviors by changing their knowledge of certain issues. Knowledge is one determinant of attitudes and behaviors, but its influence is often weak (Olson and Zanna 1993, Meadow 2005). What individuals think is important (i.e., cognitive and social factors such as values, value orientations, and attitudes), coupled with emotion, often has a stronger influence (Bruskotter et al. 2009; Skogen & Thrane 2008; Vaske 2019; Vaske et al. 2021). Education can ethically attempt to change what individuals know, but it is not always ethical or possible to influence what they value. Presenting information may induce a desired change in attitude or behavior for one group but have no influence on another group with different values. To be effective, educators must understand the values of their target audiences, how educational strategies might influence a desired outcome, and include a process for evaluating the effectiveness of strategies post-implementation.

Limited Effectiveness of Information

The availability and integration of accurate information is necessary for the public to develop educated opinions about wolves. However, information is only one of several factors which can influence public attitudes. Personal experience and the attitudes of others often affect personal opinions more than information, especially with regard to emotional and divisive issues (Borwn and Manfredo 1987, Boninger et al. 1995, Petty et al. 1997). Moreover, individuals tend to selectively accept and recall information that is consistent with their pre-existing attitudes (Olson and Zanna 1993, Petty et al. 1997). Similarly, people may interpret new information in ways that support their existing attitudes (Petty et al. 1997).

Wolves, probably more than any other wildlife species, tend to elicit strong emotions among stakeholder groups and the general public (Meadow et al. 2005). Personal views of wolves are often based on core beliefs, which are resistant to change (Fulton et al. 1996). In these cases, people are unlikely to change opinions regarding wolves based on the presentation of information alone.

As an illustration of this point, Meadow et al. (2005) assessed the influence of persuasive arguments on public attitudes regarding potential wolf restoration in the southern Rocky Mountains. They found that most people in a sample of registered Arizona, Colorado and New Mexico voters (*N*=1,300) did not change their positions after hearing arguments for and against wolf restoration. Those respondents who did change their positions generally adopted positions which were more extreme than those that were originally held (i.e., respondents who were initially opposed to restoration became more opposed and vice versa). Also, respondents tended to consider the arguments made in support of their own positions to be more persuasive than the arguments which opposed their positions.

The predisposition of people to accept or reject information based on values, value orientations, attitudes, and beliefs, especially among people who already hold strong attitudes (Bath and Phillips 1990, Thompson 1991) present significant challenges for a wolf education program.

Information Bias

Because wolves evoke a broad range of attitudes and opinions, some of which are directly opposed to each other, different groups may find difficulty agreeing on what the focus of an education program should be, or even on the facts to be presented. For this reason, another challenge of a wolf education program is to present information that is not biased toward a particular point of view. Fritts et al. (2003; page 297) noted that: "there are important and critical differences between objective wolf education and wolf advocacy or activism." Those authors cautioned that, because ethical and subjective values are often involved, "an unbiased portrayal of wolf and wolf management issues may not be possible (page 297)." Although a fair, unbiased presentation of wolf-related conflicts and potential solutions can be difficult, it is especially important when education is to be used as a tool to help resolve wolf-related conflicts among stakeholders.

Media Coverage

A third challenge facing a wolf education program involves popular presentations of wolf-related issues. Controversy tends to receive media attention and the public may receive imbalanced impressions of the extent of wolf-related conflicts (Mech 1995, Bangs and Fritts 1996). Media coverage may focus on extreme positions held by opposing stakeholder groups, potentially giving the impression the general public is more divided than it actually is. Framing of wolf management issues may also vary with respect to local outlets versus larger, national outlets (Killion et al. 2018). In a content analysis study characterizing media coverage surrounding the 2014 wolf referenda in Michigan, Gore (2016) found that policy frames were focused mostly on public participation and "power and control and not wolf biology or management" (p. 7). In addition, research has found that media coverage surrounding wolves tends to focus more on the negative impacts of wolves, with coverage generally being one-sided (Niemec et al. 2020; Houston, Bruskotter, and Fan 2010). A challenge for an education program is to achieve a balanced, accurate and objective public perspective that reflects the diversity of positive and negative impacts of wolves.

Recommended Approaches

Certain approaches can be used to help overcome the challenges described above. An early step is to define target audiences. Different audiences have different educational needs and will be receptive to different types of information and educational methods. For example, an educational program can target individuals who do not already hold strong opinions about wolves. Research has shown that such individuals are more receptive of new information (Petty et al. 1997, Williams et al. 2002).

Educational materials can be developed in partnership with multiple organizations and stakeholder groups. This approach can help ensure materials present unbiased, accurate information and it can also lend credibility to them. That is, if a person sees that materials have been developed in partnership with a group she/he trusts, that person may be more inclined to consider and accept the presented information.

Another approach is to coordinate educational programs with the media to foster the presentation of accurate information to broad audiences. This and the preceding approaches are merely a few examples of ways to increase the effectiveness of a wolf education program. The expertise of education and communication experts will be important for the development, implementation, and evaluation of these and other strategies.

Public Access to Information

Once educational materials have been developed, they can be effective only if they reach and are considered by their target audiences. Therefore, an education and outreach program must use effective ways to present information to the public.

Existing Michigan DNR Wolf-education Efforts

Although the need has been identified (Michigan Gray Wolf Recovery Team 1997), the DNR has not yet developed a comprehensive wolf information and education plan. Staff and funding limitations have precluded completion of that task to date. However, the DNR does engage in some wolf education and outreach activities:

- The DNR employs a full-time Large Carnivore Specialist. As part of their duties, they frequently give presentations to inform stakeholder groups about wolf biology, distribution and status, and ways to avoid or minimize wolf-related conflicts. Other DNR employees also give presentations on these topics. The Large Carnivore Specialist and other DNR staff regularly respond to inquiries from the media and the general public.
- The DNR responds to wolf-related media inquiries as requested on wolves and wolf populations.
- The DNR distributes information about wolf population survey results through press releases, media interviews, and “Around the State” segments on the Wildtalk Podcast.
- In cooperation with several partners, the DNR developed two brochures which provide information on ways to identify and avoid livestock losses due to predators, including wolves. Partners in brochure development included Michigan State University, Michigan State University Extension, Michigan Department of Agriculture, USDA Wildlife Services, Michigan Farm Bureau, and Michigan Cattlemens' Association. The first brochure is entitled ‘Did a Predator Kill or Injure my Livestock?’ and provides information on identifying predator depredation and steps to report a livestock kill. The second brochure, ‘How to Minimize Livestock Losses to Predators,’ suggests methods to avoid or minimize livestock depredation.
- The DNR website provides information about wolf life history, population size in Michigan, identification, recovery and legal status.
- Some DNR interpretive centers display interpretive signs which present information on wolf biology and recovery.

Chapter 10 Funding for Wolf Management

The Michigan Department of Natural Resources (DNR) is committed to the conservation, protection, management, use and enjoyment of the State's natural resources for current and future generations. Since wolves have become re-established in Michigan, they have once again become an integral part of the natural resources of the State. In the context of the DNR's mission and its implicit trust responsibilities for the State's wildlife, wolves are a necessary focus of research and management activities.

As the wolf population has grown, research and management costs have also increased. Given the widespread population and diverse management needs, the wolf program has been expensive. Due to long-term commitments to conserve and manage the wolf population, the program will continue to be expensive into the foreseeable future. Costs associated with the DNR wolf program include expenses for salaries, wages, travel, equipment, facilities, and information and education materials. In the future, additional expenses may be necessary; those additional costs will depend upon management decisions and direction.

Funding and personnel involved in wolf research and management in Michigan is provided by a variety of sources, agencies, non-governmental organizations and tribes (Tables 10.1, 10.2). Funding sources used by the DNR for wolf management have included Section 6 Endangered Species funding, the Michigan Non-game Trust fund, Wildlife Restoration funds, the Game and Fish Trust funds, and the Wildlife Conservation and Restoration and State Wildlife Grants programs.

Although Section 6 Endangered Species funding seems to be the most appropriate source for a federally listed endangered species program, funding from this source has not been available for wolf-related projects in Michigan for more than 10 years. This funding has been unavailable due to the small amounts of funding available. The majority of research and management activities in Michigan have been funded by the State, in some cases using Federal dollars earmarked exclusively for State-administered programs. A notable exception in Michigan has been the work conducted by USDA Wildlife Services. Wildlife Services personnel have been involved with the wolf program in Michigan since 2000 and have played a key role in research trapping, the winter track survey, training of field staff, and program planning.

Table 10-1 Funding sources for wolf research and management in Michigan.

Source	Type of Fund	Restricted?	Remarks
Section 6 Endangered Species	Federal, passed through to States in eight-state Region	Yes: for federally listed species only	Wolves have not been a priority for these funds for USFWS Region 3; limited availability; competitive among states
Non-Game Trust Fund	State, formerly from income tax check-off; now license plate sales	Yes: for non-game species and programs	Limited availability, especially since elimination of tax check-off, especially appropriate for education and outreach programs
Wildlife Restoration	Federal, Pittman–Robertson funds passed through to states	Yes: for birds or mammals	Traditionally used for game species only, yet not restricted to game species; available for some wolf-related work.
Game and Fish	State, derived from hunting and fishing license sales	Yes: for wildlife restoration and associated activities	Traditionally used broadly for game species and related programs; available for wolf-related work, including education and outreach
General Fund	State, derived from general tax revenues	Yes: for indemnification payments	Administered through Michigan Department of Agriculture and Rural Development
Wildlife Conservation and Restoration and State Wildlife Grants	Federal, passed through to states	Yes: for species in greatest need of conservation, which include wolves	Currently cannot be used for substantive education and outreach programs
Wolf Livestock Demonstration Project Grants	Federal, competitive grant program	Yes: for nonlethal wolf livestock depredation management projects	Only available during certain years, must apply each year

Table 10-2 Agencies and organizations involved with the Michigan wolf program.

Agency/Organization	Efforts	Remarks
Michigan Department of Agriculture	Livestock indemnification program	Also provides some technical support to livestock producers
Michigan Department of Natural Resources	All aspects of the wolf program	Primary agency responsible for all wolf-program activities
National Park Service	Logistical support, education and outreach, planning	Required by Federal Endangered Species Act to take actions to promote and enhance endangered species populations
Non-governmental Organizations	Education, outreach and advocacy efforts	
Safari Club International – Michigan Involvement Committee	Funding for specialized equipment and travel	Has provided direct funding for DNR-sponsored research projects on wolves
Tribes	Winter track surveys, education and outreach, planning	
Universities	Research, education and outreach	Now includes social research
USDA Forest Service	Logistical support, NEPA compliance for National Forest land, education and outreach, planning	Required by Federal Endangered Species Act to take actions to promote and enhance endangered species populations
USDA Wildlife Services	Research, track surveys, depredation trapping, training, planning	Designated as agents of the State
U.S.D.I. Fish and Wildlife Service	Administrative and logistical support, some funding for attitude survey pilot project and equipment, some funding oversight, Nonlethal wolf depredation management	Primary Federal agency responsible for endangered species management

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