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Livestock and domestic dog predations by wolves in Michigan

Justin L. Edge,[1] Green Mountain College, One Brennan Circle, Poultney, VT 05764, USA *justinledge@gmail.com*
Dean E. Beyer Jr., Michigan Department of Natural Resources and Environment, 1990 US 41 South, Marquette, MI 49855, USA
Jerrold L. Belant, Carnivore Ecology Laboratory, Forest and Wildlife Research Center, Mississippi State University, P.O. Box 9690, Mississippi State, MS 39762, USA
Mark J. Jordan, Green Mountain College, One Brennan Circle, Poultney, VT 05764, USA
Brian J. Roell, Michigan Department of Natural Resources and Environment, 1990 US 41 South, Marquette, MI 49855, USA

Abstract: Wolves (*Canis* spp.) have recolonized the Great Lakes region and expanded into agricultural areas where there is increasing concern of conflict with livestock. We documented 121 wolf predation events on captive or domestic animals in the Upper Peninsula (UP) of Michigan between April 1996 and April 2009. We investigated the relationship between annual wolf abundance and predation events, seasonality of predations on livestock, and the association between previous winter severity and predations on livestock. The annual number of predations on livestock increased with wolf abundance, and overall, predations on cattle and calves increased during calving season. We observed a direct relationship between the annual number of predations on livestock and previous winter severity. We observed no relationship between the annual number of domestic dogs killed by wolves and wolf abundance. If the observed trends persist, wolf–livestock conflict in the UP will continue to increase, elevating management costs and likely reducing human tolerance for wolves. Managers should be prepared for continued conflicts as wolf populations increase and eventually are delisted in the region.

Key words: *Canis lupus familiaris*, human–wildlife conflicts, livestock predation, Michigan, wolf

Human–wildlife conflicts refers to any interaction between wildlife and humans that results in adverse effects on people, wildlife, or resources used by either (Madden 2004). Due to an increasing human population, human–wildlife conflicts are more frequent (Bagchi and Mishra 2006) and prevalent across taxa (Miller et al. 1996, Struhsaker and Siex 1996, Laubhan and Gammonley 2001, Gallagher and Prince 2003). Further, species involved in human–wildlife conflicts often are rare or polarizing (e.g., endangered carnivores; Carrol et al. 2001, Treves et al. 2004, Graham et al. 2005).

Successful conservation of carnivore populations, while limiting adverse interactions with humans, can be difficult to achieve (Gillingham and Lee 1999). Human–wildlife conflicts involving carnivores often are controversial, resulting in human safety issues and loss of property (Löe and Röskaft 2004). The successful recovery of carnivore populations and their coexistence with humans depend on the ability of managers to limit human–carnivore conflicts.

Wolves (*Canis* spp.) historically have conflicted with human interests and posed serious management problems (Linnell et al. 1999, Treves and Karanth 2003). The potential for conflicts between wolves and humans exists, especially in rural areas where livestock production occurs, as wolves prey on all ungulate species available, including livestock (Fritts et al. 2003). Livestock and domestic dog losses due to wolves are of serious concern and have been documented throughout wolf range (Young and Goldman 1944, Bibikov 1982, Musiani and Paquet 2004).

Wolves were extirpated from many regions of North America, largely due to conflicts with livestock and loss of their habitat (Mech 1970). Wolves in the Great Lakes region that are purported to be *Canis lupus*, *C. lycaon*, and their hybrids (Wilson et al. 2000, Kyle et al. 2006, Wheeldon and White 2009), continue to recover and expand into rural areas where livestock production occurs (Ruid et al. 2009).

[1]Present Address: Michigan Department of Natural Resources and Environment, 1990 US 41 South, Marquette, MI 49855, USA

An increase in conflicts with livestock and rising costs for livestock protection and wolf control have resulted in regions of the United States where wolf populations have recovered (Bangs et al. 2004, Kaartinen et al. 2009).

Few studies have examined the relationship between wolf abundance and predations on domestic dogs. According to Ruid et al. (2009), dogs used for hunting were killed by wolves proportionally more than were house pet dogs in the Great Lakes region. As wolf populations recover and occupy more rural regions where hunting with dogs is allowed, predations on domestic dogs are likely to increase.

Many domestic dogs killed by wolves in the Great Lakes region are dogs engaged in bear hunting, causing seasonal variation in dog losses during the fall hunting season (Ruid et al. 2009). Seasonal variation of predations on livestock has also been suggested (Musiani et al. 2005, Chavez and Gese 2006, Ruid et al. 2009). Increased rates of cattle predation occur during domestic calving season (Cole 1966, Gunson 1983, Fritts et al. 1992). Cattle, especially calves, are most vulnerable to predation during this time, which typically occurs in early summer (Gilliland 1995). Concurrent with typical calving seasons, wolves rear their young, thus, increasing their demands for energy (Malm and Jensen 1993).

Wolf predation rates on livestock may be inversely related to the previous winter's severity (Mech et al. 1988, Fritts et al. 1992). Following mild winters, lower nutritional stress is placed on natural prey, such as white-tailed deer (*Odocoileus virginianus*) fawns, making them less vulnerable to predation (Mech et al. 1988). Consequently, wolf predations on livestock may increase following mild winters.

An improved understanding of factors related to wolf predations on livestock and domestic dogs in the Great Lakes region would allow for better preparation, management, and alleviation of future conflicts. Our objective was to characterize temporal trends in wolf predations on livestock and dogs in the Upper Peninsula (UP) of Michigan. Specifically, we were interested in addressing the relationship between annual wolf abundance and predation events, seasonality of predation events in relation to wolf energetics and domestic calving season, and the association between previous winter severity and livestock predations.

Methods

We used records of verified wolf predation events that occurred between April 15, 1996, and April 14, 2009, provided by Michigan Department of Natural Resources and Environment (MDNRE). A verified predation event consisted of ≥1 domestic or captive animals being killed or injured in a single occasion and the cause of death or attack is confirmed and attributed to wolves by MDNRE personnel or their agent (e.g., U.S. Department of Agriculture, Wildlife Services). Predation events were initially categorized into 2 groups based on whether the victim was livestock or a dog. Livestock was further categorized as cattle, sheep, white-tailed deer, and small animals (i.e., chickens, ducks, geese, pheasants, turkeys, and rabbits). Dogs were separated into bear hunting dogs and house pet dogs because bear hunting dogs may experience increased predation risk by wolves during black bear (*Ursus americanus*) training and hunting activities (Ruid et al. 2009). We digitized and mapped predation event locations using a geographic information system (ArcMap 9.3.1, ESRI, Redlands, Calif.). We summarized predation events by date, year (April 15, 1996, to April 14, 2009; Fuller 1989, Potvin et al. 2005), prey type (e.g., cattle, dog), animal description, and event type (i.e., injured or killed).

To evaluate the relationship between wolf abundance and number of predations on livestock and domestic dogs, we compared annual MDNRE minimum abundance estimates of wolves (Michigan Department of Natural Resources 2008, Roell et al. 2009) with predation events using simple linear regression. We used χ^2 analyses to compare frequency of wolf predations on livestock during late summer (July to September), as well as all cattle and calves only during calving season (typically, April to June) pooled across years, to the number of predation events during the remainder of the year.

We compared previous winter severity index (WSI) values to frequency of predation events each year using simple linear regression to estimate if the number of wolf predation events

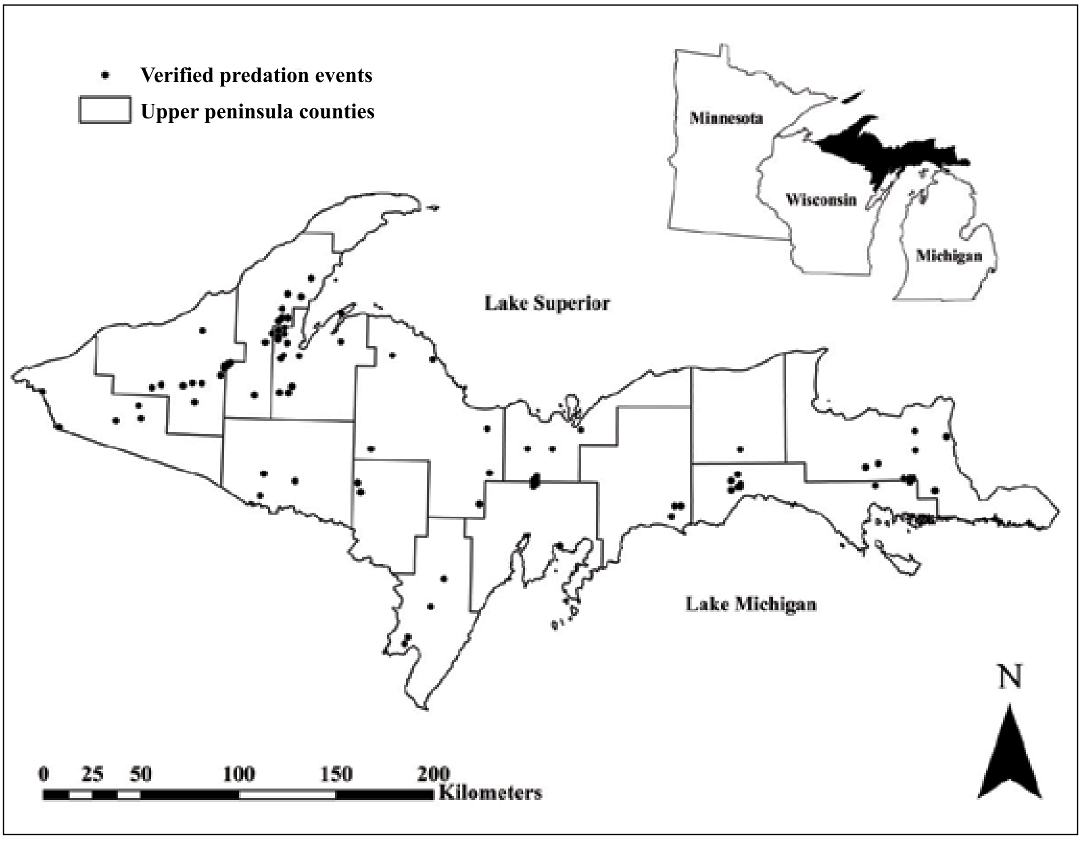

Figure 1. Distribution of wolf predation events *(n* = 121), Upper Peninsula of Michigan, April 1996–April 2009.

on livestock was inversely related to previous winter's severity. Indices of the North Atlantic Oscillation (NAO) have been used as climate proxies in many ecological studies (Drinkwater et al. 2003, Mysterud et al. 2003, Straile et al. 2003). The NAO is the dominant mode of winter climate variability in the North Atlantic region ranging from central North America to Europe and northern Asia. It consists of a north-south dipole of climate anomalies, with 1 center located over Greenland and the other center of opposite sign spanning the central latitudes of the North Atlantic between 35°N and 40°N. The NAO is derived from the difference of normalized sea level pressure between Portugal and Iceland (Hurrell 1995, Wilmers et al. 2006), using measurements from December to March to estimate WSI. Positive values are associated with reduced severity, and negative values are associated with increased severity. Winter severity as indexed by the NAO has been used previously to assess wolf–prey relationships in Michigan (Vucetich and Peterson 2004). Statistical significance for all analyses was accepted with alpha <0.10.

Results

Between 1996 and 2008, we recorded 121 verified wolf predation events (Figure 1). Predations included 87 livestock and 34 domestic dogs (20 house pet dog events and 14 bear hunting dog events); they occurred in each month and year except 1997 (Figure 2). Predation on livestock occurred in every year except 1996 and 1997 and generally increased in frequency across years (Figure 3). Seventy-seven percent of predations on livestock involved cattle, followed by sheep (10%), chickens (7%), ducks (2%), white-tailed deer (2%), pheasants (<1%), turkeys (<1%), geese (<1%), and rabbits (<1%). Predation events occasionally involved >1 type of livestock (e.g., chickens and turkeys during the same event).

Predation events resulted in the injury or death of 315 domestic or captive animals, including 76 cattle (including 5 injured), 69 chickens,

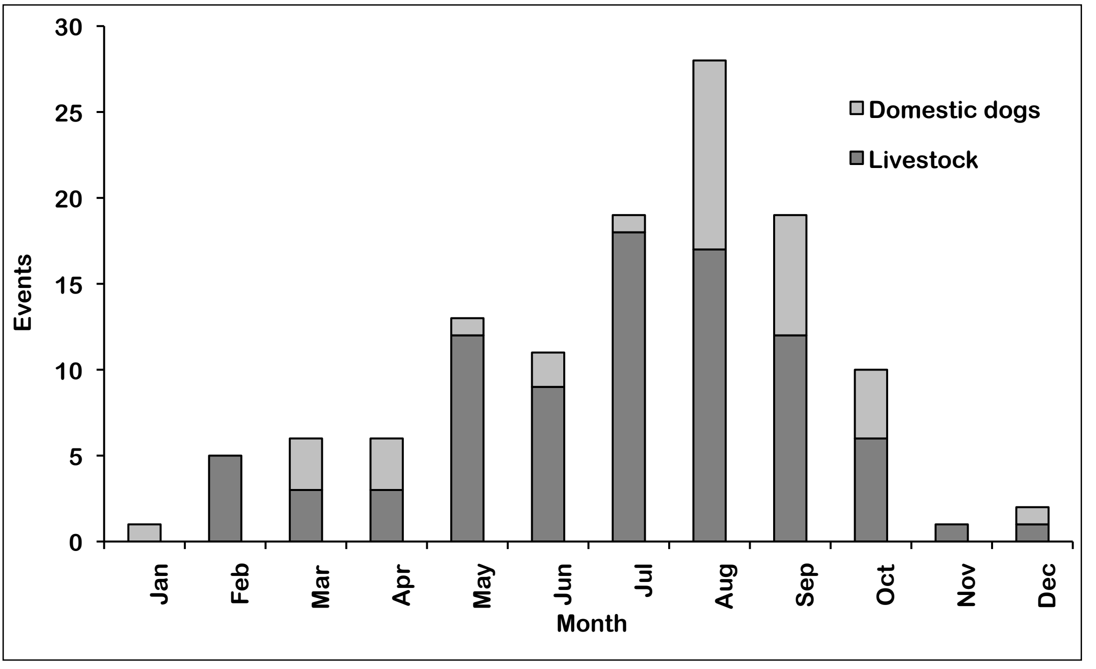

Figure 2. Wolf predation events (*n* = 121) by month on all livestock (*n* = 87) and domestic dogs (*n* = 34), Upper Peninsula of Michigan, April 1996–April 2009.

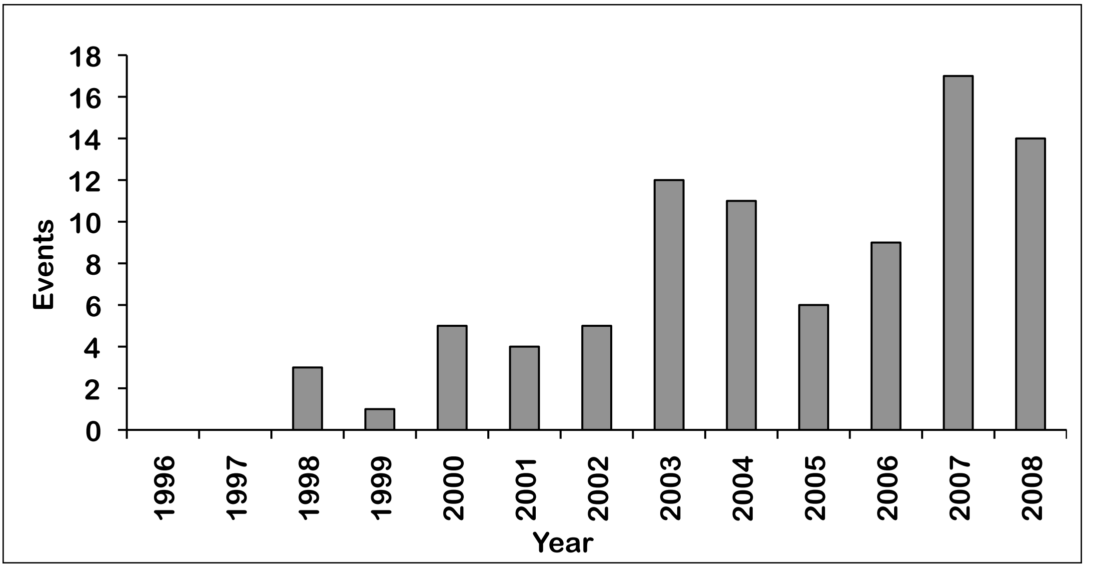

Figure 3. Wolf predation events on all livestock (*n* = 87) by year, Upper Peninsula of Michigan, April 15, 1996–April 14, 2009).

40 pheasants, 39 domestic dogs (22 house pet dogs [including 6 injured] and 17 bear hunting dogs), 38 geese, 24 sheep, 13 ducks, 12 rabbits, 7 turkeys, and 2 white-tailed deer. Ninety-eight percent of livestock predation events resulted in at least 1 animal killed, while 82% of domestic dog predation events resulted in at least 1 animal killed. A total of $40,270 was provided to livestock owners for compensation of losses. The Michigan Department of Agriculture, Defenders of Wildlife and 1 private donor provided funding.

Predation events on domestic dogs occurred in all years except 1997, 1998, and 2008 (Figure

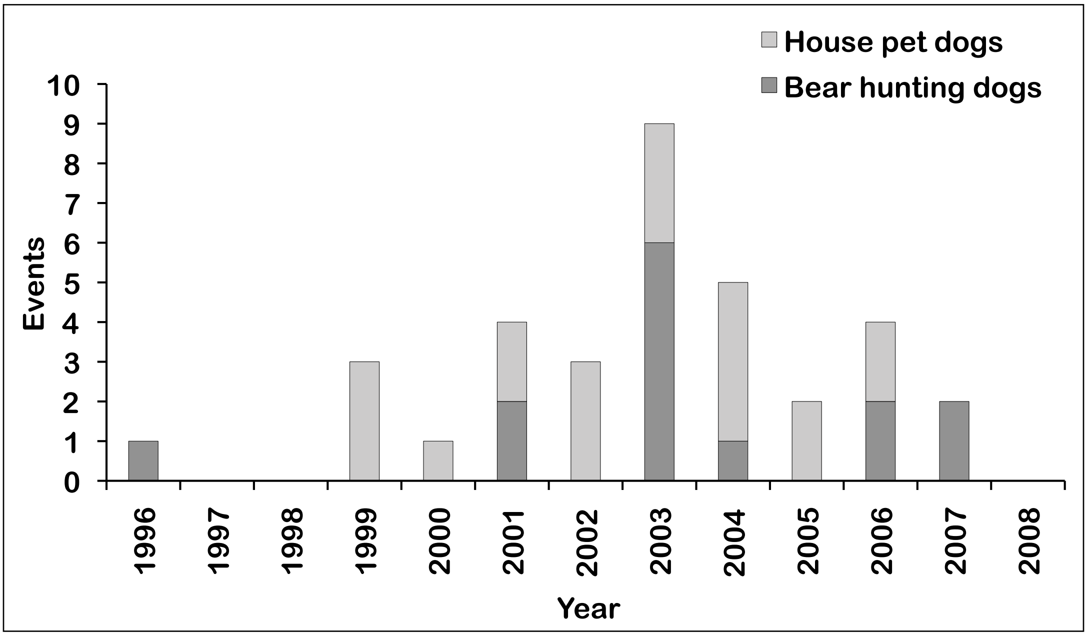

Figure 4. Wolf predation events (n = 34) by year on house pet dogs (n = 14) and bear hunting dogs (n = 20), Upper Peninsula of Michigan, April 1996–April 2009.

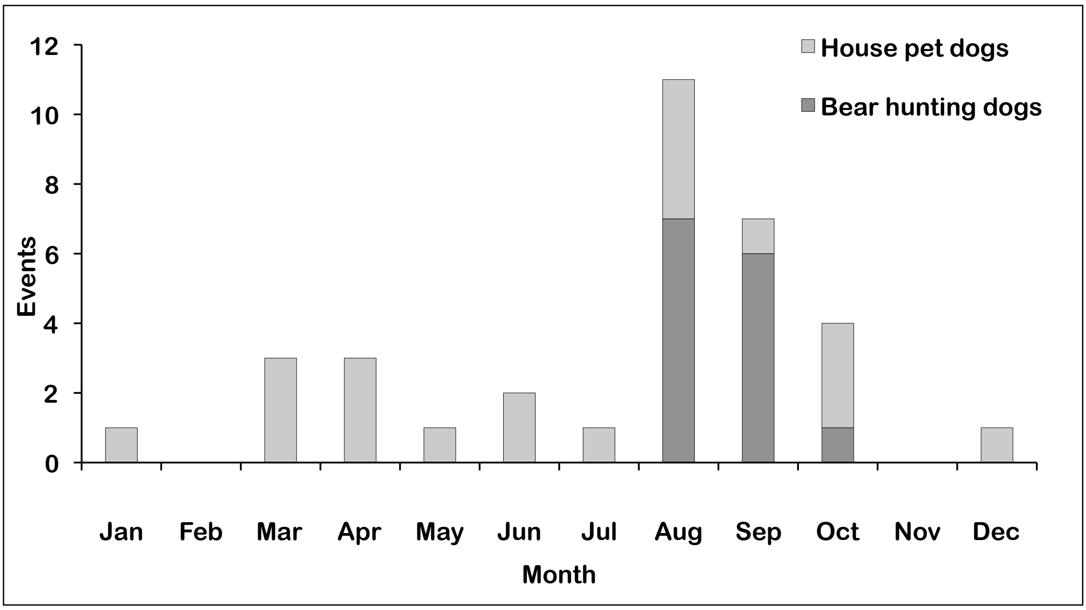

Figure 5. Wolf predation events by month on all domestic dogs (n = 34), including house pet dogs (n = 14) and bear hunting dogs (n = 20), Upper Peninsula of Michigan, April 1996–April 2009.

4). All predation events on bear hunting dogs occurred between August and October, which coincides with bear hunting and dog training in Michigan. Predations on house pet dogs occurred during every month except February and November (Figure 5). Dog owners were not compensated for their losses in Michigan.

Minimum estimates of wolf abundance increased from 116 in 1996 to 520 in 2008 (Roell et al. 2009), a 13% mean annual increase. Wolf abundance increased annually except between 1996 and 1997. Annual estimates of minimum wolf abundance were positively associated with livestock predation events ($r^2_{13} = 0.80$, $P = 0.001$;

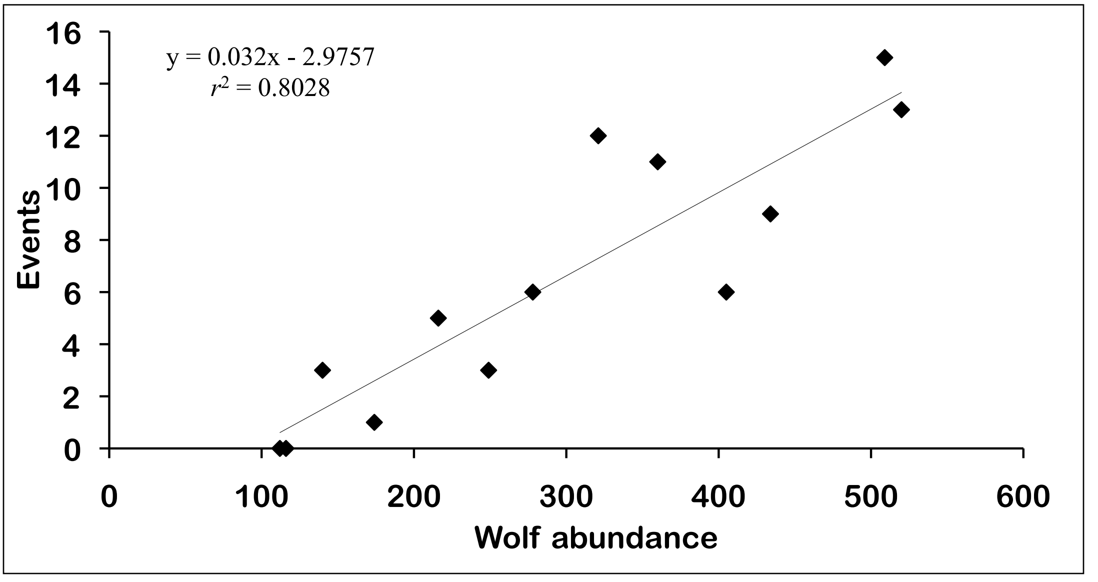

Figure 6. Relationship between wolf abundance and wolf predations on livestock (*n* = 87), Upper Peninsula of Michigan, 1996–2008.

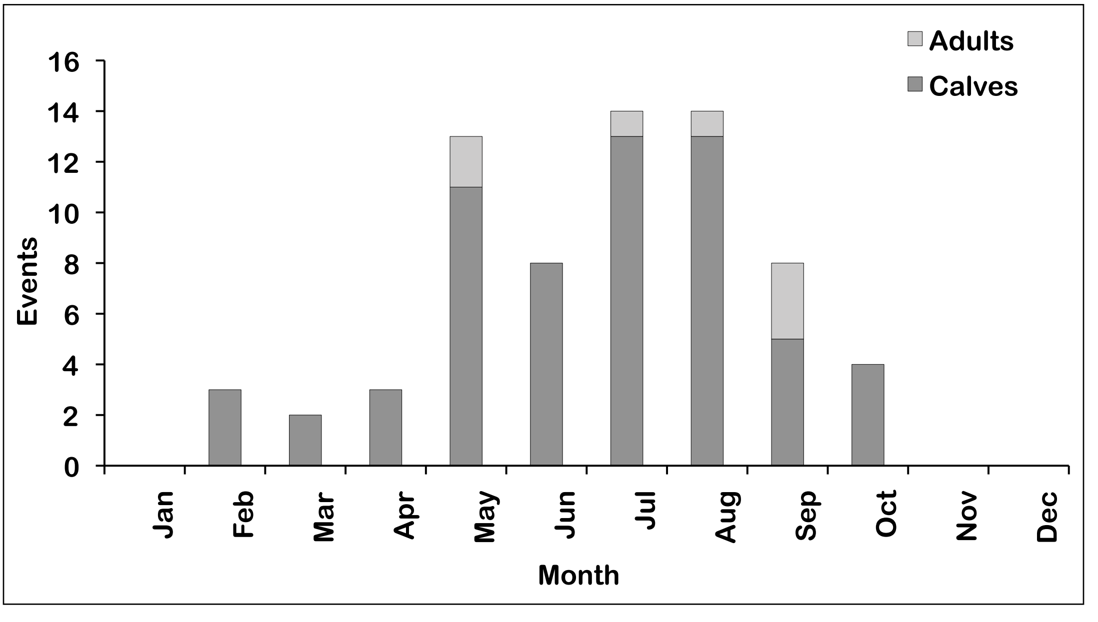

Figure 7. Wolf predation events on adult cattle (*n* = 7) and calves (*n* = 62) by year, Upper Peninsula of Michigan, April 1996–April 2009.

Figure 6), but not predations on dogs (r^2_{13} = 0.06, *P* = 0.20). The number of livestock predation events was greater (χ^2_1 = 39.08, *P* = 0.001) during late summer (July to September; *n* = 47) relative to remaining months (*n* = 40).

Seventy-seven percent of livestock predation events involved cattle (*n* = 67). Predation events on cattle occurred more frequently (χ^2_1 = 3.11, *P* = 0.08) during calving season (*n* = 23, April to June; Figure 7) relative to remaining months (*n* = 44). Ninety-three percent of cattle predation events involved calves (*n* = 62) and occurred more frequently (χ^2_1 = 3.63, *P* = 0.06) during calving season (*n* = 22; Figure 7) than the remaining months (*n* = 40).

The winter-based NAO index from December

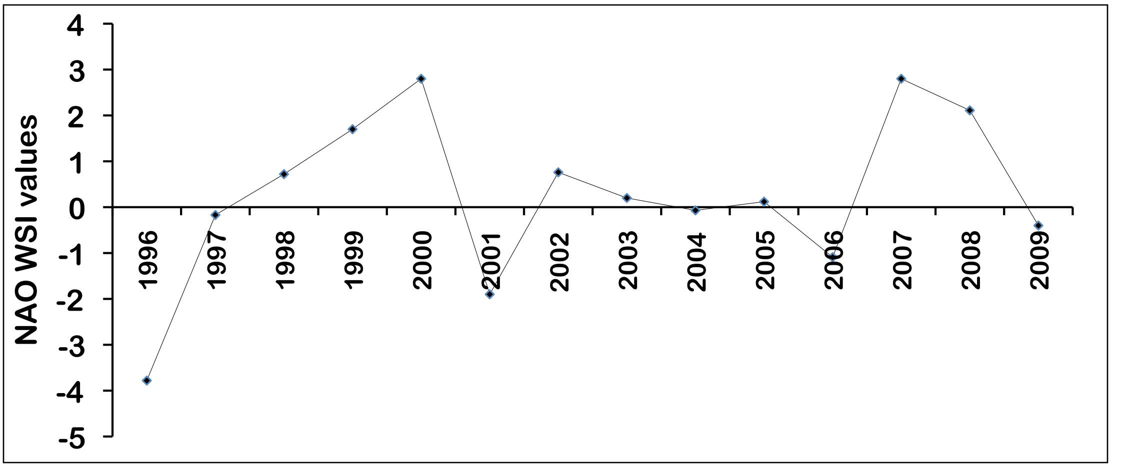

Figure 8. North Atlantic Oscillation Index (NAO) for the Eastern United States, December 1995–March 2009. Positive values correspond to reduced winter severity, and negative values correspond to increased severity.

1995 through March 2009 showed a mean positive value of 0.27 (Figure 8), with the mildest winters (2.80) occurring in 2000 and 2007 and the most severe winter (-3.78) occurring in 1996. Between 1996 and 2008, the number of predation events was inversely related to the severity of previous winters (i.e., positively correlated with NAO values; $r^2 = 0.20$, $P = 0.06$, $n = 13$).

Discussion

The potential for conflict between wolves and humans exists throughout wolf range, but it is greater in rural areas where livestock production occurs, as wolves typically prey on all ungulate species available, including domestic livestock (Young and Goldman 1944, Mech 1970, Fritts et al. 2003, Musiani et al. 2005). Further, an increase in wolf abundance contributes to overall risk of predation (Musiani et al. 2003, Kaartinen et al. 2009). Thus, the number of livestock farms and abundance of wolves in the Great Lakes region may contribute to the overall risk of predation. For example, livestock farms in Minnesota's wolf range numbered approximately 8,500 between 1997 and 2006, of which 0.9% annually had verified wolf predations (U.S. Department of Agriculture, Wildlife Services, unpublished data). In Wisconsin, there are about 2,000 livestock farms within wolf range (U.S. Department of Agriculture 2002), of which about 1% have predations annually (Ruid et al. 2009). In contrast, there are about 900 livestock farms in Michigan's wolf range (Roell et al. 2009), of which 50 were affected with wolf predations between 1996 and 2008 (<1% on average, annually).

The positive relationship observed between wolf abundance and the number of livestock predation events in the UP during the study period (1996 to 2008) suggests that for every 100 additional wolves in the population there will be about 3 additional livestock predation events per year (Figure 6). In Wisconsin, the winter 2008 estimate of wolf abundance was similar to minimum abundance estimates in the UP (576 in Wisconsin and 520 in Michigan; Roell et al. 2009, Wydeven et al. 2009), for every additional 100 wolves in the population there will be about 8 additional livestock predation events (calculated using data from 2002 [339 wolves] to 2008 [576 wolves]; Wydeven et al. 2003, 2004, 2005, 2006, 2007, 2008, 2009). The greater than two-fold number of livestock farms within wolf range in Wisconsin (about 2,000 in Wisconsin versus 900 in Michigan; U.S. Department of Agriculture, Wildlife Services, unpublished data; Ruid et al. 2009) contributes to the proportionally higher expected annual number of predation events.

In contrast to livestock, we observed no relationship between annual predation rates on domestic dogs and wolf abundance. However, we found a significant relationship for Wisconsin ($r^2 = 0.66$, $P = 0.02$, $n = 7$; calculated using 2002 to 2008 data; Wydeven et al. 2003, 2004, 2005, 2006, 2007, 2008, 2009). Underreporting of domestic dog losses may occur in Michigan; however, the number is unknown because Michigan, unlike Wisconsin, does not compensate owners for domestic dog losses to wolves in the Great Lakes region. Domestic dogs that are used to hunt black bear often are released at bear-bait sites that may have been visited by wolves (Ruid et al. 2009). Baiting for bear hunting in Wisconsin begins much earlier (April) than in Michigan (August), which may partially explain the disparity we observed between Michigan and Wisconsin.

Bear hunting dogs may be at a greater risk to predation by wolves than other domestic dogs. Bear hunting dogs are generally at a greater distance from humans during hunting activities and more often in areas occupied by wolves, factors that may increase their vulnerability to wolf predation. In the UP, a single pack of wolves was likely responsible for several attacks on hunting dogs (D. Beyer, MIDNRE, unpublished data). Additionally, several dog owners reported multiple events involving hunting dogs, implying that specific areas and hunting methods could influence predation risk for hunting dogs. In contrast, predation on other domestic dogs generally occurred near human residences, and the rate of attack was relatively low across years.

Energy requirements for wolves increase during late summer when wolf packs raise their pups (Mech 1970). We found an increased number of predations on livestock between July and September (54% of all livestock predations), similar to findings in other studies (Fritts et al. 2003, Chavez and Gese 2006). Preying on domestic animals rather than on natural prey is likely more energy-efficient for wolves in Michigan because livestock, especially cattle, are kept within enclosures, often on small farms (Chavez and Gese 2006). This, combined with food requirements of pups, likely explains the increase in number of predations on livestock between July and September.

Across the Great Lakes region, fowl, followed by cattle, are the most common livestock killed by wolves (Ruid et al. 2009). Conversely, we observed cattle as the most common livestock killed by wolves in Michigan. Our results are also consistent with other studies that have shown wolves typically prey on calves (92% in Michigan) rather than on adult cattle (Fritts 1982, Gunson 1983, Bjorge and Gunson 1985, Fritts et al. 1992). Availability of cattle and their vulnerability during calving season may lead to increased wolf predations (Musiani et al. 2005). Although we found more wolf predations on calves and cattle overall during the calving season, many 3- to 4-month-old calves were killed throughout the year, suggesting increased risk during calving operations, as well as when calves are born year-round. The apparent selection for younger cattle by wolves in the UP, combined with substantial variation in calving season, suggests that managers might limit predation losses by constraining the timing of calving and increasing the use of prevention methods (i.e., fladry, flashing lights, etc.) and vigilance during times when calves are <3 months old (Bradley and Pletscher 2005).

Proven methods of limiting wolf predation include, management of birthing dates to limit exposure of young, herding vulnerable animals at night, combining herds as to not spread livestock across pastures, and locating birthing of young within barns (Mitchell et al. 2004, Sillerio-Zubrini et al. 2007, Baker et al. 2008). Excluding wolves from livestock areas containing young animals using electric fencing also reduces attacks (Wam et al. 2004). However, this option may not be economically viable. Also, compensation programs that reimburse farmers for livestock losses due to wolves should be implemented cautiously. Use of an integrated management approach that emphasizes prevention methods and includes prompt responses to predation events and judicious use of compensation, may help decrease predation events, increase tolerance, and alleviate economic losses caused by wolf predations.

Previous studies have shown that severe winters reduce the physical condition of wolves' natural prey, such as white-tailed deer and moose (*Alces alces*), during the following spring, thereby increasing prey availability (Mech et al. 1988, Post et al. 2002, Stenseth et al. 2002, Walther et al. 2002). Consequently, mild winters may increase wolf predations on domestic and captive animals during these periods, due to reduced vulnerability of natural prey following milder winters. The inverse relationship that we observed between predations on livestock and previous winter severity supports this assertion.

Worldwide resurgence of wolf populations is associated with conflict over domestic animals (Treves et al. 2004, Gula 2008, Kaartinen et al. 2009). Management of this conflict is critical to long-term conservation efforts. If the observed trends persist, wolf–livestock conflict in the UP will continue to increase and remain an issue, elevating costs associated with compensation programs and likely reducing human tolerance for wolves. Furthermore, the eventual delisting of wolves in the Great Lakes region will perhaps lead to a higher demand for both lethal and nonlethal management methods, increasing costs even more. Managers should be prepared for continued conflicts in the future between wolves and livestock as wolf populations recover across the U.S, including the Great Lakes region.

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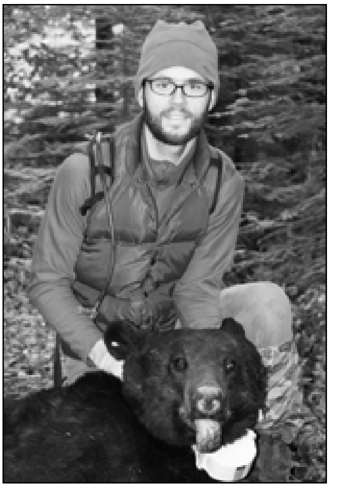
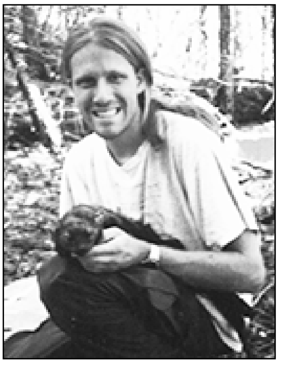


Justin L. Edge is a research assistant for the Michigan Department of Natural Resources and Environment. He received his B.S. degree from Berry College and his M.S. degree from Green Mountain College. His research interests include canid ecology, predator–prey interactions, and wolf–human conflicts.

Dean E. Beyer Jr. is a wildlife research biologist with the Michigan Department of Natural Resources and Environment. He received his B.S. degree from the University of Vermont and his M.S. and Ph.D. degrees from Michigan State University. His research interests include population dynamics, abundance estimation, and predator–prey interactions.

Jerrold L. Belant is an assistant professor in the Department of Wildlife, Fisheries, and Aquaculture at Mississippi State University. He received his B.S. and M.S. degrees from the University of Wisconsin–Stevens Point and his Ph.D. degree from the University of Alaska–Fairbanks. His research interests include carnivore ecology, resource selection, and human–wildlife conflicts.

Brian J. Roell is a wildlife biologist for the Michigan Department of Natural Resources and Environment where he specializes in wolves. He received his B.S. degree from Northern Michigan University and his M.S. degree from the University of Northern Colorado. His interests include furbearer and moose ecology and human–wildlife conflicts.



Mark J. Jordan is an assistant professor of biology at Green Mountain College. He received his B.S. degree from the University of Puget Sound and his Ph.D. degree from University of California–Berkeley. His research focuses on population monitoring of carnivores, particularly in developing and using noninvasive methods, such as camera-trapping and genetic tagging with hair snares.