Making Room for Wolf Recovery:

The Case for Maintaining Endangered Species Act Protections for America's Wolves

Saving Wildlife for 25 Years

CENTER for BIOLOGICAL DIVERSITY

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November 2014

I. Executive Summary

In 2011 the U.S. Fish and Wildlife Service removed Endangered Species Act protections for wolves in the northern Rocky Mountains and western Great Lakes, arguing that wolves were recovered in those regions and the states could be trusted to manage them. But all of the states with substantial wolf populations have enacted aggressive hunting and trapping seasons that are intended to drastically reduce wolf populations. To date these hunts have resulted in the killing of more than 2,800 wolves. The deaths of so many wolves have contributed to declines in wolf populations of 9 percent in the northern Rockies and 25 percent in Minnesota. Given increased efforts to kill wolves in many states, these declines can be expected to continue and likely increase.

Despite the nightmare that state management of wolves has been, the Fish and Wildlife Service has proposed to remove protections for gray wolves in the remainder of the lower 48 states, excluding a small portion of Arizona and New Mexico, where the Mexican gray wolf struggles to survive. The agency argues that growth of populations in the northern Rockies and Great Lakes is sufficient to consider the species recovered and to remove Endangered Species Act protections.

In this report, we make the case that the job of recovering wolves is far from complete by:

- Identifying and mapping suitable habitat not currently occupied by wolves;
- Documenting dispersals of wolves to this habitat;
- Detailing the limitations of current management plans;
- Highlighting the important roles wolves play in ecosystems.

Gray wolves currently occupy less than 10 percent of their historic range and a fraction of currently suitable habitat. To identify and map unoccupied, suitable wolf habitat in the United States, we used 27 studies that model wolf habitat in different regions to create a single map. Based on this analysis, there is up to 530,000 square miles of suitable wolf habitat in the United States, only roughly 171,000 square miles of which is occupied, demonstrating that wolves currently occupy only about 30 percent of existing suitable habitat. The southern Rocky Mountains, Grand Canyon, Cascade Mountains in Washington, Oregon and California, the Sierra Nevada and the Adirondacks are all places that could support wolf populations. According to the studies, these areas are capable of supporting a minimum of 5,000 wolves, which would nearly double the existing wolf population.

Recovering wolves to these additional areas is necessary to ensure the long-term survival of gray wolves in the lower 48 states and enrich the diversity of U.S. ecosystems that have lacked the gray wolf as a top predator for decades. At last count the three existing wolf populations combined include only roughly 5,400 wolves, which is below what scientists have identified as the minimum viable population size necessary to avoid extinction. Considering that populations are now declining and isolated at several scales, doubling the population by facilitating wolf recovery in additional areas is needed to secure the future of gray wolves in the U.S.

Studies following reintroduction of wolves to Yellowstone National Park have documented that wolves as top predators play pivotal roles in shaping the structure and function of ecosystems, benefitting a wide range of species, including beavers, songbirds, grizzly bears, foxes, bison, pronghorn and more.

Gray wolves are also a substantial draw for people from around the world. Millions of people have traveled to Yellowstone from around the world to see the gray wolves reintroduced in 1995 and 1996, and polls consistently show that a broad majority of the American public supports the recovery of gray wolves, including to new areas where they don't currently occur.

Wenaha pack male courtesy ODFW
Cover photo by Chris Smith / Flickr

II. Introduction

Gray wolves once occupied the majority of North America, excluding perhaps only the driest deserts and the southeastern United States, where the red wolf occurs (FWS 2013). Scientists estimate that pre-European settlement there may have been as many as 2 million wolves in North America (Leonard et al., 2005). During the late 19th century and early 20th century, state and local bounties reduced wolf numbers. From 1915 through mid-century, the U.S. government exterminated wolves from the United States and Mexico (Seton, 1929; Young and Goldman, 1944). By 1967, when wolves were protected under a precursor to the Endangered Species Act, they had been reduced to fewer than 1,000 wolves in northeastern Minnesota (FWS 2009).

With protection, wolves began to see some recovery, but only in portions of their former range where the U.S. Fish and Wildlife Service (FWS) developed recovery programs. Wolves were originally protected as four subspecies -- the northern Rockies wolf, eastern wolf, Mexican wolf and Texas wolf (FWS 1978). Recognizing that these subspecific designations were potentially invalid, FWS consolidated protection for gray wolves to the species level in 1978, including the entire lower 48 states (Ibid.) The agency, however, never developed a national strategy to recover wolves in the lower 48 in line with expanded protection. Instead it completed recovery plans that had already been started in 1978 for three of the four purported subspecies, excluding the Texas wolf.

With recovery programs in place, including reintroduction of wolves in portions of the northern Rocky Mountains, wolves began to grow in number and expand their range in the northern Rockies and western Great Lakes states. Mexican wolves were also reintroduced to a portion of the Southwest, but their numbers have grown slowly. In 2003 FWS began moving to delist wolves in the northern Rockies and western Great Lakes, and after multiple rounds of litigation in which the agency was repeatedly found not to have followed best science, were successful in removing protections in both regions in 2011 (FWS 2011ab). Since delisting, all states in the northern Rockies and western Great Lakes have instituted aggressive hunting and trapping seasons intended to drastically reduce wolf populations.

The agency is now proposing to remove protections for wolves across the lower 48 excluding a portion of the range of the Mexican gray wolf in Arizona and New Mexico (FWS 2013). This proposal disregards that there are only roughly 5,400 wolves in portions of the Midwest (~3,700 wolves), northern Rockies (~1,670) and Southwest (~80) (FWS 2013), and the states are actively working to reduce populations. Moreover, wolves occupy just a fraction of their historic range, less than 10 percent, and only a small portion of existing suitable habitat. Indeed, multiple researchers have modeled extensive suitable habitat for wolves in the Northeast, Pacific Northwest, southern Rocky Mountains, California and elsewhere. To describe the full extent of suitable habitat available for further recovery of wolves, we reviewed literature estimating existing wolf habitat, created composite maps of all known wolf habitat in the lower 48, quantified unoccupied habitat, and estimated the minimum number of wolves that could occur in this habitat. We also quantified and mapped wolf dispersal events over the past 30 years. In the following discussion, we present the results of these analyses, further discuss the history of efforts to remove protections for wolves, including discussion of the current proposal, and provide a rationale for not walking away from wolf recovery now.

III. Studies Estimating Wolf Habitat in the United States

We reviewed 27 studies that modeled potential wolf habitat in the lower 48 states and used the composite results to estimate and map the full range of potential unoccupied wolf habitat and the number of wolves that could be supported in the lower 48 (Appendix A). The studies modeled wolf habitat across the western United States, the upper Midwest and the Northeast (Appendix B). This likely encapsulates a majority of existing wolf habitat in the United States excluding the range of the red wolf in the Southeast. But there may be additional habitat in North and South Dakota and other areas that should be the subject of additional modeling.

Predictive modeling parameters used in the studies consisted of road density (26 studies), human population density (20 studies), prey density (20 studies) and land cover/use (16 studies). Some studies used additional parameters including

land ownership (11 studies), livestock density (7 studies), slope or elevation (5 studies), climate or snowfall (4 studies), surface water availability (4 studies), and prey accessibility or availability (3 studies). Two studies used soil depth or hydrology (Appendix C).

and the Sierra Nevada in California. In the northeastern United States, thousands of square miles of terrain spanning upstate New York and portions of Vermont, New Hampshire and Maine were identified as capable of supporting a wolf population. And some studies indicate the lower peninsula of Michigan could support wolves.

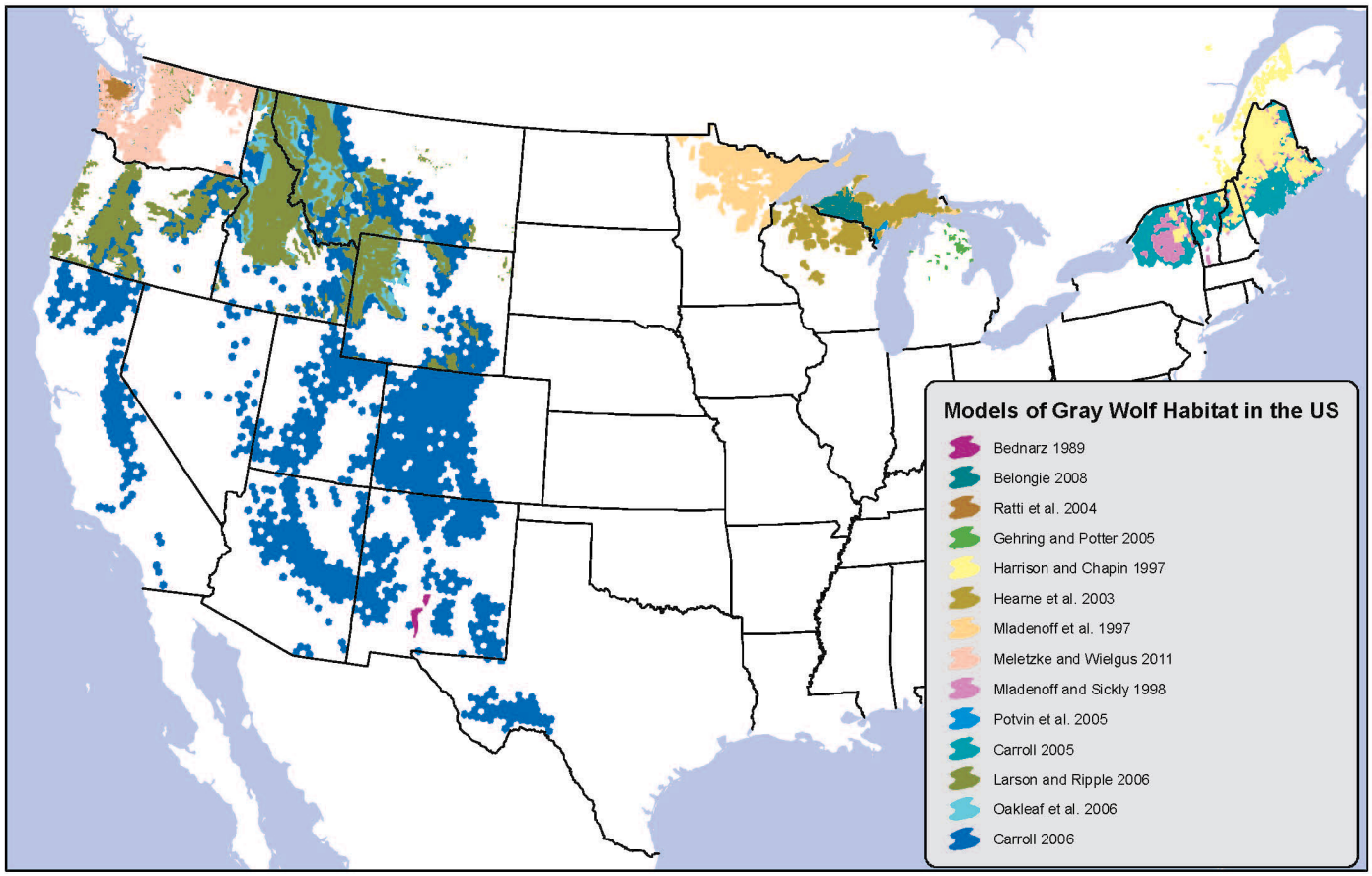

Figure 1. Suitable gray wolf habitat in the contiguous United States as identified in 14 modeling studies.

Past modeling of wolf habitat has accurately predicted wolf occupancy in both the northern Rockies and Midwest, suggesting modeling can accurately convey potential wolf habitat. We used 14 of the 27 studies to create a composite map of wolf habitat for the lower 48 states (Figure 1). We did not use all of the studies because in some cases they represented different modeling iterations for the same areas by the same authors, and in others there was insufficient spatial information to allow mapping.

Reviewed studies identified extensive wolf habitat in regions where wolves have not yet recovered. In the western United States, this includes the central and southern Rocky Mountains in both Colorado and Utah, the Grand Canyon and surrounding areas in northern Arizona, the Olympic Peninsula in Washington, the Cascade Mountains in Washington, Oregon and California

According to our mapping, there are approximately 530,000 square miles of suitable wolf habitat in the lower 48, of which roughly 171,000 square miles are currently occupied, meaning wolves have recovered to only roughly 30 percent of known suitable habitat. Although not all studies estimated the number of wolves that could be supported, those that did suggest that at least another 5,000 wolves could populate the Northeast, southern Rockies, West Coast and Southwest, nearly doubling the existing population and creating a network of interconnected populations bolstering genetic security.

IV. Wolves Are Dispersing Into Areas of Suitable Habitat and Need Endangered Species Act Protections to Survive

Not only is there extensive suitable habitat in other

regions of the country, but wolves are dispersing into this habitat. Wolves can travel substantial distances traversing diverse landscapes when leaving their birth-packs to seek mates and territory of their own (Mech and Boitani, 2003). The most-recent and well-known example is that of wolf OR-7, who traveled more than 4,000 miles after dispersing from his birth pack in northeastern Oregon to travel to California and back into Oregon repeatedly during 2011-2014. He recently found a mate, with whom he has denned and produced pups in southwestern Oregon just north of the California border. In order to quantify and visually display these dispersal events, we tabulated all known wolf dispersals between 1981 and 2014 in which wolves dispersed to areas and states outside of existing core recovery areas (Appendix D). The dispersals we tabulated were reported in newspaper stories, agency reports and other sources, and for each dispersal event we attempted to obtain a point of origin and endpoint. We identified 56 dispersal events in total, with an average dispersal distance of 264 miles. This data shows that wolves have and will continue to move into suitable habitat on the West Coast, southern Rocky Mountains and Northeast, where they need protection if they are going to survive and establish populations (Figure 2). Indeed, with protections under the Endangered Species Act, wolves were able to move into Oregon and Washington from both the northern Rockies and British Columbia and form fledgling populations.

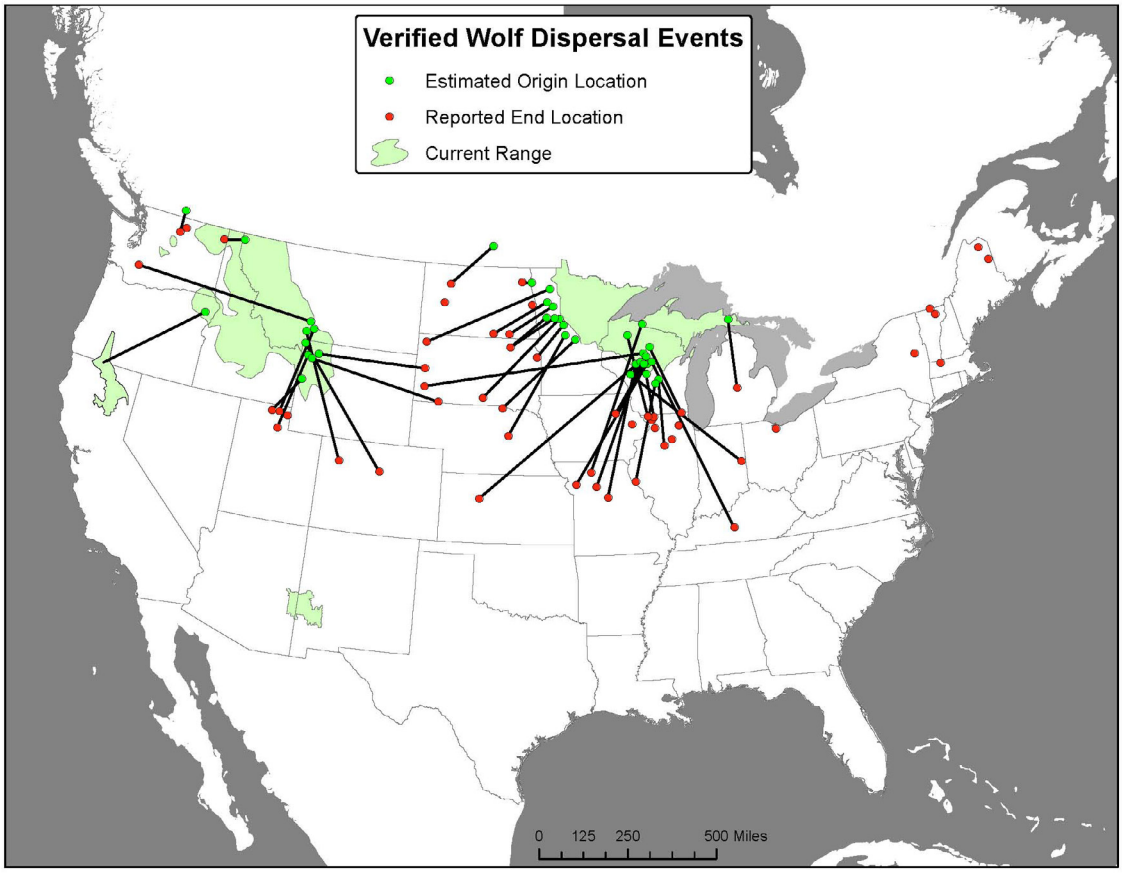

Figure 2. Dispersals by wolves to locations outside of core federal recovery areas, 1981-2014.

Our data also shows dispersal events steadily increased from 2000 to 2011, when populations were steadily growing with endangered species protections in place, and appear to have since declined now that all states with substantial wolf populations have enacted aggressive hunting and trapping seasons, leading to population declines (Figure 3). This further highlights the need for continued protection both in areas that support source populations and in areas to which wolves are dispersing.

V. Recovery of Wolves to Additional Areas is Required by the Endangered Species Act

Unlike previous endangered species statutes, the Endangered Species Act does not simply require recovery of species to the point that they are not at risk of global extinction. Indeed, the primary purpose of the Act is to conserve the ecosystems upon which endangered species depend (16 U.S.C. § 1531(b)). Significantly, the Act defines an endangered species as any species in danger of extinction in all or a *significant portion of its range* (16 U.S.C § 1532(6)). This means that a species need not be at risk of extinction everywhere to qualify for protection, but rather only in a significant portion of range. Accordingly, it also means that species cannot be considered recovered until no longer endangered in any significant portion of range. As demonstrated by the 27 studies we reviewed, wolves remain absent or at very low numbers over significant portions of their historic range where there

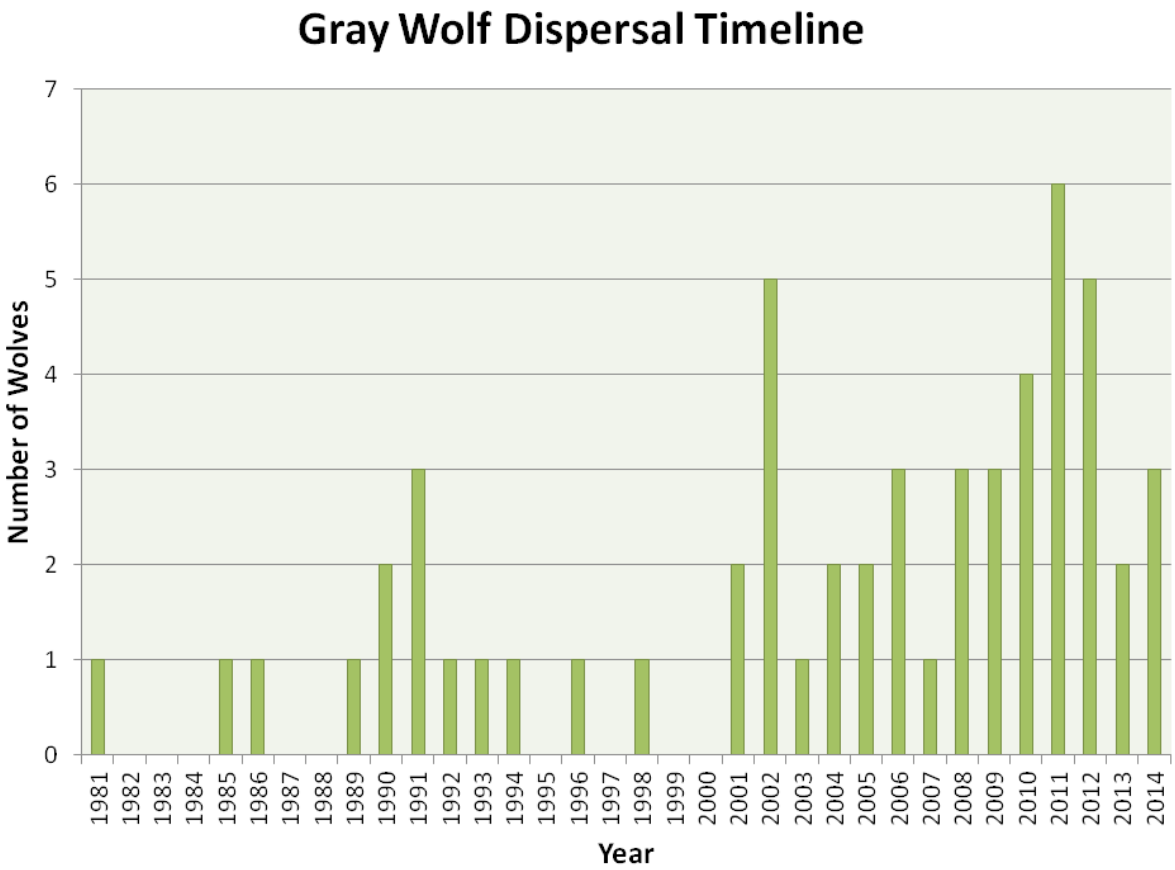

Figure 3. Annual gray wolf dispersal events to areas and states outside of federal core recovery areas.

is extensive remaining habitat, including the Northeast, southern Rocky Mountains, West Coast and elsewhere. For this reason alone, wolves remain an endangered species that continues to need the protections of the Endangered Species Act.

VI. Existing Wolf Populations Are Not Viable in the Absence of Additional Population Expansion

The existing wolf populations in the northern Rocky Mountains, western Great Lakes and Southwest are below minimum viable population sizes sufficient to ensure their survival (Shaffer, 1981; Reed et. al., 2003, Traill et al. 2007). In an analysis of 102 species including the gray wolf, Reed et al., (2003) estimated a mean and median minimum viable population of 7,316 and 5,816 individuals respectively, concluding that long-term persistence of wild populations of animals, such as wolves, requires 7,000 adult individuals. Likewise, Traill et al., (2007) combined results from studies on 212 species, including the gray wolf, finding that the median minimum viable population was 4,169 individuals.

As of the end of 2013, the existing wolf populations numbered 1,691 in the northern Rockies, 3,669 in the western Great Lakes, and 83 in the Southwest.[i] According to the above studies, which collectively examined hundreds of species, all existing wolf populations are below minimum population sizes considered necessary to ensure long-term survival.

Of further concern, wolf populations in both the northern Rockies and Great Lakes are declining in response to aggressive hunting and trapping seasons enacted by individual states. In the northern Rockies, the last population count showed a 9 percent decline since federal delisting and in Minnesota, the population declined by an estimated 25 percent between 2008 and 2012.[ii] If these population declines continue, risk to wolf populations will only increase.

Existing wolf populations are also below levels considered necessary to avoid genetic inbreeding. A number of studies have concluded that an "effective" population size of 500 individuals is necessary to avoid

[i] For northern Rockies see: http://www.fws.gov/mountain-prairie/species/mammals/wolf/annualrpt12/; for western Great Lakes see http://www.fws.gov/midwest/wolf/aboutwolves/WolfPopUS.htm.

[ii] See: *Ibid.* and www.mndnr.gov/wolves

OR-11 courtesy ODFW

the effects of genetic inbreeding (Soule and Wilcox, 1980; Frankel and Soule, 1981; Soule, 1986; Franklin and Frankham, 1998). Effective population size is defined as the number of breeding individuals, rather than total individuals, translating into a total population of 2,500-5,000 individuals to maintain a total of 500 breeding individuals (Frankham, 1995). Gray wolves in North America have already lost substantial genetic diversity because of the severe reduction in their overall historical numbers and range and further losses could lower survival and reproduction further endangering wolves (Leonard et al., 2005).

Loss of genetic diversity due to small population size and historic declines is compounded by the isolation of existing wolf populations (Soule, 1980). The Mexican gray wolf, for example, is isolated from all other wolf populations and the population in the Greater Yellowstone ecosystem is largely isolated from other wolves in the northern Rockies. This lack of connectivity further increases the potential for loss of genetic variation over time. Restoring wolves to additional suitable habitat would create more opportunity for connectivity between populations. It would also increase the likelihood that wolves dispersing from currently existing wolf populations would be able to find other wolves with whom to mate, and thus contribute genetically to the health of adjacent populations.

VII. Recovering Wolves to Additional Areas Is Necessary for Healthy, Functioning Ecosystems

The loss of large carnivores is a global problem with broad ecological consequences. Because of their position at the top of food chains, large carnivores play an inordinate role in shaping the structure and function of diverse ecosystems (Estes et al. 2011, Ripple et al., 2014). According to Ripple et al. (2014), nearly two-thirds (61 percent) of large carnivore species are considered threatened by the IUCN and most (77 percent) are declining. The extirpation of the gray wolf across most of the American landscape is no exception to this pattern and as elsewhere around the world, loss of a top predator like the gray wolf has resulted in a number of rippling ecological consequences that have negatively impacted a broad range of species. This can be inferred largely by studies showing positive trends in a broad range of species following reintroduction of wolves in the northern Rockies.

Studies following reintroduction of wolves to Yellowstone National Park documented that wolves had a profound and transformative impact on the landscape that benefitted a wide variety of species. In particular, the reintroduction of wolves resulted in a dramatic decrease in elk numbers and also potentially forced them to move more (Barber-Meyer et al., 2008,

Diamond pack female courtesy WDFW

Ripple and Beschta, 2012). Reduced elk browse in turn has led to recovery of woody species, such as cottonwood, aspen, willow and serviceberry (Ripple and Beschta, 2012). This has fostered many beneficial ecosystem changes, from providing crucial nesting and roosting sites for songbirds, to enhancing root strength and thereby protecting streams from soil erosion, to providing food and building sources for beavers whose dams then create cool, deep ponds needed by juvenile fish, and finally to facilitating growth of berry-producing shrubs that provide food for grizzly bears and other animals (Ripple and Beschta, 2004; Hebblewhite et al., 2005; Weiss et al., 2007; Eisenberg et al., 2013, Hollenbeck and Ripple, 2008, Ripple et al., 2013).

Wolves prey on wild ungulates which are the most vulnerable due to factors such as age, injury or ill-health, allowing greater numbers of healthier, more robust, and more alert animals to survive and pass on their genes (Stahler et al, 2006). Wolves may also prevent the spread of diseases among prey species by culling sick animals before they infect others (Wild et al., 2005). Wolves view coyotes as territorial competitors and in some parts of Yellowstone wolves have greatly decreased the coyote density. This has led to increases in numbers of foxes and increased survival of pronghorn antelope fawns due to reduced predation by coyotes (Berger et al., 2008). Carcasses of elk killed by wolves provide food for a host of other scavenger species, including but not limited to grizzly bears, black bears, coyotes, eagles, ravens, magpies and hundreds of species of beetles (Smith et al., 2003). Wolf-kills may also provide a buffering effect against climate change for carrion-feeders that depend on carcasses for food. As warming temperatures result in decreased winter severity, and thus a decreased die-off of vulnerable animals that would otherwise succumb to harsh weather, wolf-kills will provide the carcasses scavengers need to survive (Wilmers and Getz, 2005).

The ecosystems of the southern Rocky Mountains, Colorado Plateau, Grand Canyon, Cascade Mountains, Adirondack Mountains, Sierra Nevada and elsewhere would all benefit from the return and recovery of the gray wolf. It is not enough to restore the wolf to small fragments of its historic range. Instead, large carnivores like wolves should be restored to population levels allowing them to once again be "ecologically effective" – that is, a population that has enough individuals and a wide enough geographic distribution so that not just the species' existence has been reestablished but, also, its essential role in nature (Soule et al., 2003; Carroll et al., 2006.)

VIII. Maintaining Federal Protections for Wolves Is Essential Because States Cannot Be Trusted to Conserve Existing Wolf Populations or Protect Wolves Dispersing to Other Areas

Following removal of Endangered Species Act protections in the northern Rockies and western Great Lakes, all of the states with substantial wolf populations enacted aggressive hunting and trapping seasons designed to drastically lower populations, and indeed population declines are occurring. In the three years since protections were removed, nearly 3,000 wolves have been killed through state-sanctioned "harvest" seasons. The killing of so many wolves in such a short time directly reflects the negative prejudices towards wolves held by powerful minorities in all of these states. These prejudices were the primary cause of the extirpation of the wolf across significant portions of its range and highlight why wolves continue to need federal protections and a national recovery plan.

Worse still, anti-wolf policies appear to be getting more severe in most states where protections have been removed. In Idaho, for example, wolf hunting is allowed year round, including during breeding season and has resulted in the death of at least 1,000 wolves and reduced the state's wolf population by around 23 percent from its 2008 peak. This not being enough, the Idaho Department of Fish and Game in January 2014 hired a bounty hunter to pack into the Frank Church-River-of-No-Return Wilderness where he killed nine wolves; has sent U.S. Department of Agriculture/Wildlife Services' airborne sharpshooters into the Clearwater National Forest where 48 wolves have been killed in six operations; and Gov. Butch Otter this spring signed into law a bill that establishes a wolf-control board and provides over $600,000 annually to kill most of Idaho's remaining wolves.[iii] In Montana, the state wildlife commission nearly doubled the number of wolves that can be killed by an individual hunter or trapper in 2013 compared to 2012, and extended the wolf-killing season through the middle of March (when wolves would be pregnant.) In Wyoming, wolves were designated a predatory animal that can be killed at anytime by nearly any means, including killing pups in dens, in nearly 85 percent of the state and designated the rest of the state outside of Yellowstone and Grand Teton National Parks, a trophy game area, where hunting of wolves was permitted. This management was found to be inadequate by a federal court in September, 2014 and Endangered Species Act protections were reestablished, stopping the 2014-2015 hunt and killing of wolves in the predatory zone.

In Minnesota, the state had promised in its state wolf plan that there would be no hunting or trapping of wolves for five years post delisting, but instead instituted wolf hunting and trapping immediately following delisting. To date, at least 650 wolves have been killed and the population declined by 25 percent between 2008-2012. Starting in 2012, Wisconsin authorized wolf-hunting and trapping that has to date resulted in killing of 374 wolves with a goal of reducing the population by more than half to 350 wolves from over 800. Wolves are allowed to be hunted and trapped with the use of hounds, night-hunting by artificial lights, and baiting, despite overwhelming public opposition to any of these practices.[iv] Michigan's governor in 2013 signed a bill allowing its state department of natural resources to institute hunting of wolves despite citizens having collected over a quarter of a million signatures to place a no-wolf-hunting measure on the election-season ballot; a second signature-collecting effort has resulted in a second ballot measure to overturn the newly-signed wolf-hunting law, but a pro-hunting ballot measure was just passed by the legislature. Because the no-wolf hunting ballot measure must be decided by the voters in the November election, Michigan wolves have received a temporary reprieve and there will be no wolf-hunting season in Michigan this year. But if the no-hunting measure does not pass, the legislative bill will go into effect in March meaning Michigan's wolves will once again be facing legal harvest and certain death. Finally, in South Dakota, the state passed a law that classifies wolves in the eastern half of the state as "varmints" that can be shot on sight.

[iii] See: http://gazers.com/previously-endangered-wolves-can-now-exterminated-idaho/

[iv] Wisconsin Department of Natural Resources 2013 wolf hunting and trapping regulations; The Political Environment, April 12, 2013

IX. **Conclusion**

In its rush to remove federal protections for gray wolves in most of the lower 48, the U.S. Fish and Wildlife Service relied on the states to adequately manage and conserve the species. As these examples above demonstrate, however, state management of wolves has been a political, rather than a science-based, endeavor. In the three years states have had wolf-management authority, nearly 3,000 wolves have been killed from hunting and trapping, sanctioned by state policies that fail to adequately consider the long-term viability or need for further recovery of wolves.

The Service's plan to now remove federal protections throughout most of the remaining lower 48 states and allow states to fully manage wolves not only jeopardizes the future of existing wolf populations it also makes it nearly impossible for dispersing wolves to make their way to adjacent states to establish new populations of wolves.

To achieve true, long-term, sustainable, recovery of the gray wolf, federal wolf protections should be maintained and recovery plans developed, with the goal of restoring connected, resilient, ecologically-effective wolf populations wherever suitable wolf habitat exists. Formation of a recovery team made up of the many highly-qualified wolf biologists and other scientists could ensure that considerable recent science is brought to bear and ultimately produces a scientifically and legally defensible recovery strategy that specifies the conditions under which wolves are downlisted and ultimately delisted in all or portions of the species' range. Restoring wolves to these areas would fulfill the ESA's mandate to recover threatened or endangered species throughout all significant portions of their ranges and to conserve the ecosystems upon which they depend.

Yellowstone wolf by doublejwebers / Flickr

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APPENDIX A: Wolf Habitat Modeling Literature Reviewed

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APPENDIX B: Predicted Wolf Habitat Area and Wolf Populations

Reference	Study Region	Method	Study Location	Suitable Wolf Habitat (mi2)	# of Wolves Region Could Support
Bednarz 1989	Southwest	LANDSAT	White Sands Missile Range, NM	996	32-40
Belongie 2008	Midwest	GIS Overlay, Expert Ranking	MI's Upper Peninsula	4,846	-
Bennett 1994	S. Rockies	Unweighted Ranking	CO	12,000 - 25,000	407 – 814
Carroll 2003	Northeast	PATCH	ME (2025)	-	1,030
			NH (2025)	-	68
			NY (2025)	-	338
			VT (2025)	-	50
Carroll et al. 2001	West Coast	GIS Index	OR & CA	48,494	-
			Northeast OR		100
			Southwest OR and Northern CA		190 – 470
Carroll et al. 2003	S. Rockies		-	-	>1,000
Carroll et al. 2004	Southwest	PATCH	Blue Range AZ/NM, Grand Canyon, AZ, Mogollon Rim, AZ, San Juans, CO, Vermejo/Carson, NM, UT	17,390 - 24,131	3,166
Carroll et al. 2006	Western U.S.		-	233,081	-
Gehring and Potter 2005	Midwest	Per Mladenoff et al. 1995	MI	849-1,634	40 – 105
Harrison and Chapin 1997	Northeast	ARC Info and GIS	ME	17,064	-
			NY	5,644	-
			NH	1,773	-
			VT	954	-
			MA	20	-
			ME & NH	-	488
			Adirondacks, NY	-	146
Hearne et al. 2003	Midwest		MI & WI	-	>1,000
Houts 2001	N. Rockies	Logistic Regression	Central ID, GYE, Western MT	27,751	-
Houts 2003	West Coast	Logistic Regression	OR & WA	9,730	-
	N. Rockies		Central ID, GYE, Western MT	117,000	-
Johnson et al. 1992	Southwest		AZ	14,099	-
Larsen and Ripple 2006	N. Rockies	Logistic Regression	OR, ID, MT, WY	26,448	1,450

APPENDIX C: Predictive Modeling Parameters Used in 27 Wolf Habitat Suitability Models for the Lower 48 United States

Reference	Road density	Human density or disturbance	Land cover/use	Land use/owner	Prey density	Prey accessability	Prey availability	Livestock density	Climate or snowfall	Slope or elevation	Soil depth / hydrology	Surface water availability
Bednarz 1989												
Belongie 2008	x	x	x		x							
Bennett 1994												
Carroll et al. 2001	x	x		x	x	x						
Carroll et al. 2003	x	x			x		x					
Carroll et al. 2004	x	x	x		x			x				
Carroll et al. 2006	x	x										
Carroll 2003	x	x			x							
Carroll 2005	x	x	x		x				x	x		
Gerhing and Potter 2005	x											
Harrison and Chapin 1997	x	x	x									
Hearne et al. 2003	x	x		x								
Houts 2001	x		x	x	x							
Houts 2003	x		x									
Johnson et al. 1992	x	x	x	x				x	x			x
Larsen and Ripple 2006	x	x	x	x	x		x		x			
Maletzke and Wielgus 2011												
Mladenoff and Sickly 1998	x				x							
Mladenoff et al. 1995	x	x	x	x	x							
Mladenoff et al. 1997	x		x	x	x							
Mladenoff et al. 1999	x											
Oakleaf et al. 2006	x	x	x	x	x			x		x		
Paquet et al. 1999	x		x		x					x	x	
Potvin et al. 2005	x				x							
Ratti et al. 2004	x	x		x	x			x		x		
Sneed 2001	x	x	x	x	x							x
Wydevan et al. 1998	x	x			x							

APPENDIX D: Tabulation of Dispersing Wolves, 1981-2014

Date	Reported End Location	Estimated Origin Location	Estimated Dispersal Distance (mi)	Outcome	Source
3/15/81	Brown County, South Dakota	Minnesota	139	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
10/13/85	Dickey County, North Dakota	Minnesota	154	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
6/4/86	Harding County, South Dakota	Unknown	349	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
11/10/89	Brown County, South Dakota	Minnesota	158	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
2/27/90	McIntosh County, North Dakota	Minnesota	185	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
2/2/90	Walsh County, North Dakota	Minnesota	29	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
2/27/91	Mountrail County, North Dakota	Manitoba, Canada	167	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
12/1/91	Grant County, South Dakota	Minnesota	126	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm

12/22/91	Tripp County, South Dakota	Minnesota	329	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
1/6/1992	Dunn County, North Dakota	Unknown	213	Shot and killed	Licht, D.S. and S.H. Fritts. 1998. Gray Wolf (Canis lupus) occurrences in the Dakotas. U.S. Fish and Wildlife Service. Jamestown, ND: Northern Prairie Wildlife Research Center Online. Accessed at: http://www.npwrc.usgs.gov/resource/mammals/wolves/index.htm
Aug-93	Northeast Maine	Unknown	Unknown	Shot and killed[1]	Maine Wolf Coalition. Wolves in the Northeast. Accessed at: http://mainewolfcoalition.org/wolves-in-the-northeast/; New York Times. 1996. Signs Suggest a Return Of Timber Wolf to Maine. Accessed at: http://www.nytimes.com/1996/12/22/us/signs-suggest-a-return-of-timber-wolf-to-maine.html
1994/95	Boyd County, Nebraska	Western Great Lakes DPS	300	Shot and killed	U.S. Fish and Wildlife Service. 2011. Revisiting the Listing of the Gray Wolf in the Western Great Lakes. Federal Register, Vol. 76, No. 249.
Nov-96	Eastern Maine	Unknown	Unknown	Shot and killed	Maine Wolf Coalition. Wolves in the Northeast. Accessed at: http://mainewolfcoalition.org/wolves-in-the-northeast/; New York Times. 1996. Signs Suggest a Return Of Timber Wolf to Maine. Accessed at: http://www.nytimes.com/1996/12/22/us/signs-suggest-a-return-of-timber-wolf-to-maine.html
Nov-98	Glover, Vermont	Unknown	Unknown	Shot and killed	Maine Wolf Coalition. Wolves in the Northeast. Accessed at: http://mainewolfcoalition.org/wolves-in-the-northeast/; Urbigkit, C. 2007. Wolf killed in Vermont. Pinedale Online! Accessed at: http://www.pinedaleonline.com/news/2007/10/WolfkilledinVermont.htm
2001	Harding County, South Dakota	Western Great Lakes DPS	400	Killed	U.S. Fish and Wildlife Service. 2011. Revisiting the Listing of the Gray Wolf in the Western Great Lakes. Federal Register, Vol. 76, No. 249.
Dec-01	Day, New York	Unknown	Unknown	Shot and killed (MC)	Maine Wolf Coalition. Wolves in the Northeast. Accessed at: http://mainewolfcoalition.org/wolves-in-the-northeast/; Nearing, B. 2011. A century later, the wild wolf returns: Animal shot a decade ago hints at the arrival of predator in New York. Times Union. Accessed at: http://www.timesunion.com/local/article/A-century-later-the-wild-wolf-returns-2222681.php
Feb-02	Pend Oreille County, Washington	Northwestern Montana	Unknown	Moved into B.C.	Wiles, G.J., H.L. Allen, and G.E. Hayes. 2011. Wolf conservation and management plan for Washington. Washington Department of Fish and Wildlife, Olympia, Washington. 297 pp.

10/23/02	Outside of Trenton, Grundy County, Missouri	Ironwood, Gogebic County, Michigan	470	Shot and killed	Michigan Department of Natural Resources. 2008. Michigan Wolf Management Plan. Wildlife Division Report No. 3484. Accessed at: http://www.michigan.gov/documents/dnr/Draft_Wolf_Management_Plan_030708_227742_7.pdf; Beringer, J. Personal communication with Jeff Beringer, Resource Scientist, Missouri Department of Conservation. May 9, 2013.
Dec-02	Henry, Marshall County, Illinois	Wisconsin	200	Shot and killed (MC)	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
12/15/02	Spalding, Greeley County, Nebraska	Western Great Lakes DPS	350	Shot and killed	U.S. Fish and Wildlife Service. 2003. Status of Gray Wolf Recovery, Weeks of 3/28 to 4/04, 2003. Weekly Report, Gray Wolves in the Northern Rocky Mountains. Accessed at: http://www.fws.gov/mountain-prairie/species/mammals/wolf/WeeklyRpt03/wk04042003.htm
2002	Morgan, Utah	Yellowstone NP	240	Trapped and released in Yellowstone	Hollenhorst, J. 2002. Wolf Capture in Utah Ignites Controversy. KSL-TV. Accessed at: http://web.ksl.com/dump/news/cc/local/wolf_return.php
2003	Southwest (SW 1/4 Sec. 10, T19N, R13E) Randolph County, Indiana	Jackson County, Wisconsin	428	Found dead	Wisconsin Department of Natural Resources. 1999. Wisconsin Wolf Management Plan. Madison, Wisconsin. Accessed at: http://dnr.wi.gov/files/pdf/pubs/er/er0099.pdf; http://www.predatormastersforums.com/forums/ubbthreads.php?ubb=showflat&Number=89261
6/7/04	I-70, 30 mi west of Denver, Colorado	Northwest corner of Yellowstone NP	446	Killed by motor vehicle	U.S. Fish and Wildlife Service. 2004. News Release: Preliminary Necropsy Results For Gray Wolf Found Dead Near Denver, Colorado. U.S. Fish and Wildlife Mountain-Prairie Region, Lakewood, Colorado. Accessed at: http://www.fws.gov/mountain-prairie/pressrel/04-43.htm
Oct-04	Lower Peninsula, Michigan	Upper Peninsula, Michigan	Unknown	Killed	U.S. Fish and Wildlife Service. 2011. Revisiting the Listing of the Gray Wolf in the Western Great Lakes. Federal Register, Vol. 76, No. 249.
2/17/05	Chain O'Lakes State Park, Lake County, Illinois	Wisconsin	Unknown	Killed by motor vehicle	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
Dec-05	New Canton, Pike County, Illinois	Central Wisconsin	300	Shot and killed	U.S. Fish and Wildlife Service. 2011. Revisiting the Listing of the Gray Wolf in the Western Great Lakes. Federal Register, Vol. 76, No. 249; University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Young, C. 2006. Wild wolf killed in Pike County Illinois. Wolf Saga. Accessed at: http://wolfsaga.blogspot.com/2006/02/wild-wolf-killed-in-pike-county.html; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.

Apr-06	Sturgis, South Dakota	Yellowstone NP	300	Killed by motor vehicle	Maughan, R. 2006. Wolf hit on I-90 near Sturgis, SD last April was a Yellowstone area wolf. Wolf Report 8-15-2006. Accessed at: http://www.forwolves.org/ralph/sturgis-wolf.htm; Stark, M. 2007. Yellowstone wolf hit near Sturgis. The Billings Gazette. Accessed at: http://helenair.com/news/article_cee1229e-ec91-575c-a7ea-30287aac9b33.html
Oct-06	North Troy, Vermont	Unknown	Unknown	Shot and killed	Maine Wolf Coalition. Wolves in the Northeast. Accessed at: http://mainewolfcoalition.org/wolves-in-the-northeast/; Urbigkit, C. 2007. Wolf killed in Vermont. Pinedale Online! Accessed at: http://www.pinedaleonline.com/news/2007/10/WolfkilledinVermont.htm
2006	Tremonton, Utah	Northern Rocky Mountain DPS	Unknown	Killed	U.S. Fish and Wildlife Service. 2007. Rocky Mountain Wolf Recovery 2006 Annual Report. C.A. Sime and E.E. Gangs, eds. USFWS, Ecological Services, 585 Shepard Way, Helena, Montana. 59601. 235 pp.
Oct-07	Shelburne, Massachusetts	Unknown	Unknown	Shot and killed	Maine Wolf Coalition. Wolves in the Northeast. Accessed at: http://mainewolfcoalition.org/wolves-in-the-northeast/; Reitz, S. 2008. Rare Gray Wolf Appears in Western Massachusetts. National Geographic News. Accessed at: http://news.nationalgeographic.com/news/2008/03/080305-AP-wolf-return.html
2/19/08	Lena, Illinois	Western Great Lakes DPS	Unknown	Shot and killed (MC)	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
2008	Okanogan County, Washington	"Coastal B.C. and NE B.C., NW Alberta, or reintroduced populations in central ID and GYE"	Unknown	Unknown	Wiles, G.J., H.L. Allen, and G.E. Hayes. 2011. Wolf conservation and management plan for Washington. Washington Department of Fish and Wildlife, Olympia, Washington. 297 pp.
Jul-08	Twisp, Washington	Coastal/Southern British Columbia	Unknown	Unknown	U.S. Fish and Wildlife Service. 2011. Rocky Mountain Wolf Recovery 2010 Interagency Annual Report. C.A. Sime and E.E. Bangs, eds. USFWS, Ecological Services, 585 Shepard Way, Helena, Montana, 59601.
2009	Kane County, Illinois	Unknown	Unknown	Shot and killed (MC)	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
Apr-09	South of Meeker, Colorado	South of Bozeman, Montana	400	Killed by Compound 1080	The Southwest Environmental Center. 2011. Lone wolf travels 3,000 miles before being poisoned. Accessed at: http://www.wildmesquite.org/news/lone-wolf-travels-3000-miles-being-poisoned/071511

May-09	Pend Oreille County, Washington	Northwestern Montana/northern Idaho	Unknown	Unknown	Wiles, G.J., H.L. Allen, and G.E. Hayes. 2011. Wolf conservation and management plan for Washington. Washington Department of Fish and Wildlife, Olympia, Washington. 297 pp.
Mar-10	Bellevue, Sandusky County, Ohio	Unknown	Unknown	Shot and killed	Butterworth, S. 2013. Personal communication with Scott Butterworth, District Manager, Wildlife District Two, Ohio Department of Natural Resources. May 14, 2013.; http://www.toledoblade.com/StevePollick/2010/03/19/Wolf-shooting-piques-curiosity.html
Jul-10	Rich County, Utah	Unknown	Unknown	Shot and killed	Linnell, M. 2013. Personal communication with Mike Linnell, State Director, Utah, USDA-Wildlife Services. May 10, 2013.
2010	Cache County, Utah	Northern Rocky Mountain DPS	Unknown	Shot and killed in Idaho	Love, C. 2010. Wolf Range Expands into Utah. Field and Stream. Accessed at: http://www.fieldandstream.com/blogs/hunting/2010/07/wolf-range-expands-utah
2010	12 miles northeast of Carrolton, Carroll County, Missouri	Western Great Lakes DPS	Unknown	Shot and killed (MC)	Jerek, J. 2013. DNA shows hunter-shot canine from October to be wandering wolf. Missouri Department of Conservation. Accessed at: http://mdc.mo.gov/newsroom/dna-shows-hunter-shot-canine-october-be-wandering-wolf; Beringer, J. Personal communication with Jeff Beringer, Resource Scientist, Missouri Department of Conservation. May 9, 2013.
2011	Western Washington	Northern Rocky Mountain DPS	Unknown	Two packs established outside of NRM DPS	U.S. Fish and Wildlife Service. 2012. Northern Rocky Mountain Wolf Recovery Program 2011 Interagency Annual Report. M.D. Jimenez and S.A. Becker, eds. USFWS, Ecological Services, 585 Shepard Way, Helena, Montana, 59601.
2011	Southeast Jo Daviess County, Illinois	Unknown	Unknown	Shot and killed (male)	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
2011	Southeast Jo Daviess County, Illinois	Unknown	Unknown	Shot and killed (female)	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
Jan-11	Hillsboro, North Dakota	Unknown	Unknown	Shot and killed (MC)	Associated Press. 2011. Federally protected gray wolf shot in North Dakota. Twin Cities Pioneer Press. Accessed at: http://www.twincities.com/news/ci_17555251
Oct-11	Clinton County, Missouri	Western Great Lakes DPS	Unknown	Shot and killed (MC)	Beringer, J. Personal communication with Jeff Beringer, Resource Scientist, Missouri Department of Conservation. May 9, 2013; Leonard, J. 2012. Gower man unknowingly bags wolf. News-Press Now. Accessed at: http://www.newspressnow.com/sports/outdoors/article_917229af-fbd3-5ba4-9386-05f9e928cec9.html

12/28/11	Northern California	Northeastern Oregon (Imnaha pack)	350	Travelled back to Oregon in March 2013	Oregon Department of Fish and Wildlife. 2013. Wolves in Oregon: Wolf Program Updates. Accessed at: http://www.dfw.state.or.us/wolves/; California Department of Fish and Wildlife. Wildlife and Habitat Management: OR-7 - A Lone Wolf's Story. Accessed at: http://www.dfg.ca.gov/wildlife/nongame/wolf/OR7story.html
Feb-12	Custer County, South Dakota	Western Great Lakes DPS	Unknown	Killed	Woster, K. 2012. Wolf killed near Custer likely from Great Lakes population. Rapid City Journal. Accessed at: http://rapidcityjournal.com/news/wolf-killed-near-custer-likely-from-great-lakes-population/article_92dc1eb8-6be8-11e1-8ce3-001871e3ce6c.html; Custer County Chronicle Online. 2012. Wolf killed near Custer. Accessed at: http://www.custercountynews.com/cms/news/story-427443.html
May-12	Pine Ridge, South Dakota	Southeast Yellowstone NP	400	Found dead, likely hit by motor vehicle	Woster, K. 2012. Wolf found near Pine Ridge migrated from Yellowstone. Rapid City Journal. Accessed at: http://rapidcityjournal.com/news/wolf-found-near-pine-ridge-migrated-from-yellowstone/article_f6d01210-9f07-11e1-a76d-001a4bcf887a.html
Oct-12	Franklin Island Conservation Area, Howard County, Missouri	Western Great Lakes DPS	Unknown	Shot and killed (MC)	Jerek, J. 2013. DNA shows hunter-shot canine from October to be wandering wolf. Missouri Department of Conservation. Accessed at: http://mdc.mo.gov/newsroom/dna-shows-hunter-shot-canine-october-be-wandering-wolf; Beringer, J. Personal communication with Jeff Beringer, Resource Scientist, Missouri Department of Conservation. May 9, 2013.
Dec-12	Trego County, Kansas	Western Great Lakes DPS	Unknown	Shot and killed (MC)	Kansas Department of Wildlife, Parks and Tourism. 2013. Weekly News: Wolf Found In Kansas. Accessed at: http://kdwpt.state.ks.us/KDWPT-Info/News/Weekly-News/1-31-13/WOLF-FOUND-IN-KANSAS; Peek, M. 2013. Personal Communication with Matt Peek, Wildlife Research Biologist, Kansas Department of Wildlife, Parks & Tourism. May 10, 2013.
Dec-12	Coleta, Whiteside County, Illinois	Unknown	Unknown	Trapped and released	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
Mar-13	Apple Canyon Lake, Jo Daviess County, Illinois	Wisconsin	250	Found dead	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
Dec-13	La Salle County, IL	Unknown	Unknown	Killed by vehicle	University of Illinois. 2013. Wildlife Directory: Gray Wolf (Canis lupus). Accessed at: http://web.extension.illinois.edu/wildlife/directory_show.cfm?species=wolf; Kath, J.A. 2013. Personal Communication with Joseph A. Kath, Endangered Species Manager, Illinois Department of Natural Resources. May 15, 2013.
Mar-14	Munfordville, Kentucky (Hart County)	Western Great Lakes DPS	750	Shot and killed	Associated Press. 2013. Officials confirm gray wolf killed in Ky. Accessed at: http://www.wkyt.com/home/headlines/officials-confirm-gray-wolf-killed-in-ky-219749481.html

Feb-14	Fairbank, Iowa (Buchanan County)	Western Great Lakes DPS	250	Shot and killed (MC)	Love, Orlan. 2014. First wolf in Iowa in 89 years killed in Buchanan County. Accessed at: http://www.kcrg.com/subject/news/first-wolf-in-iowa-in-89-years-killed-in-buchanan-county-20140506
May-14	Jones County, Iowa	Awaiting info from Iowa DNR	Unknown	Shot and killed (MC)	Love, Orlan. 2014. http://thegazette.com/subject/environment/nature/endangered-species/another-wolf-slain-in-iowa-20140717

MC – Wolf was mistaken for coyote when shot.
[1] shot by bear hunter who was prosecuted by USFWS