Chapter 6
History, Population Growth, and Management of Wolves in Wisconsin

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Preface While we were growing up in Wisconsin during the 1950s and 1960s, gray wolves (we always called them timber wolves, *Canis lupus*) were making their last stand in northern Wisconsin. Wolves were considered a wilderness-dependant relic of Wisconsin's frontier past that no longer belonged in our state. We did not expect wolves to ever again return to the state, at least not in any sizeable numbers. Among us, Dick Thiel was the most tenacious about trying to find evidence of wolves in Wisconsin, even as a student in the 1960s and 1970s. When wolves began returning during the mid-1970s, we dared not hope for any more than a token population of wolves to reestablish. The recovery of wolves in Wisconsin has succeeded beyond our wildest dreams. We have had the pleasure to document and track the amazing return of this powerful predator to our state.

6.1 Introduction

The gray wolf has exhibited a remarkable recovery in Wisconsin during the late twentieth and early twenty-first centuries, despite a common belief during the mid-1900s that the state was no longer wild enough to support populations of large predators such as gray wolves. In some ways, Wisconsin seems like an unlikely place for wolves to have recovered. The state's nickname, "America's Dairyland," reflects the abundance of livestock farming. Wisconsin has over 3.3 million cattle and over 5.5 million people in a land area of 140,663 km^2. Roughly half the state is forest, and in 2002, 46% was classified as farmland (Wisconsin Legislative Reference Bureau 2003). Public lands include 16.4% of the state, with major land ownership in county forests, national forests, national wildlife refuges, state forests, and state wildlife areas (Wisconsin Legislative Reference Bureau 2003). Wisconsin's largest federal or state designated wilderness area covers 73 km^2.

Despite few large wild areas, wolves were able to recolonize and again become important elements of forest ecosystems in northern and central Wisconsin. Legal protection, public education and outreach, and sound scientific management of public forest lands enabled wolves to recover and demonstrated that wolves can

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recover without extensive wilderness, provided there is adequate habitat, prey, legal protection, and public acceptance.

In this chapter, we review the history and management of wolves in Wisconsin, examine the growth and expansion of the wolf population, and speculate on the future of the wolf population with elimination of federal protection and reduction of favorable habitat caused by human landscape developments.

6.2 Early History and Initial Recolonization of Wolves in Wisconsin

Gray wolves probably have occupied Wisconsin since the last glacier receded about 10,000 years ago, and perhaps earlier in portions of southwestern Wisconsin that were not glaciated. Populations of wolves probably fluctuated with the size of ungulate populations. When the first European exploration began in 1634, wolves coexisted with herds of bison (*Bison bison*), elk (*Cervus elaphus* , and white-tailed deer (*Odocoileus virginianus*) in prairies, savannas, and oak (*Quercus*) and maple (*Acer*) forests of southern Wisconsin, and with moose (*Alces alces*), white-tailed deer, and small numbers of caribou (*Rangifier tarandus*) in the hemlock-maple (*Tsuga-Acer*), pine (*Pinus*), swamp conifers, and boreal forests and bogs of northern Wisconsin. Beavers (*Castor canadensis*) also were abundant throughout the state, but probably more so in the streams and glacial lakes of northern Wisconsin. When European settlement started in earnest during the 1830s, beavers were nearly eliminated due to unregulated trapping during the fur trade, and bison were extirpated by Native Americans after acquiring horses and firearms (Thiel 1993). Other prey such as deer, elk, and moose were probably still relatively abundant.

Jackson (1961) speculated that there were 20,000–25,000 wolves in Wisconsin at the beginning of European settlement. This would have represented an unlikely density of 142–177 wolves per 1,000 km^2. Wolf densities this high have not been documented in modern research on wolves in North America (Fuller et al. 2003). Wydeven (1993) speculated that perhaps 3,000–5,000 wolves existed at the beginning of European settlement, or about 20–35 wolves per 1,000 km^2. This estimate appears more compatible with likely prey abundance and agrees with recent research on wolf densities.

A bounty for the killing of wolves was offered by the Wisconsin Territory from 1839 through 1847, and following statehood (1848), a state bounty ran nearly continuously from 1865 to 1957 (Thiel 1993). Bounties were paid to private trappers and hunters for killing wolves and coyotes (*Canis latrans*), and both species were listed as wolves in bounty records. After 1947, when wolves had declined to very low numbers, wolves were distinguished from coyotes in the bounty records (Thiel 1993). Unlike western states, federal and state governments made no concerted effort to eliminate wolves in Wisconsin. Rangeland grazing of livestock was not practiced across northern Wisconsin, and livestock were normally kept in small fenced pastures near farmsteads. Nonetheless, unregulated hunting and trapping, as

well as the incentive of bounty payments, caused the eventual collapse of the wolf population in Wisconsin.

Thiel (1993) documented the decline of wolves in Wisconsin that occurred from the 1800s to the1950s. The wolf population declined from about 200 in the early 1920s, to a scattered remnant of lone wolves spread across the north in the late 1950s. By 1960, wolves were considered extirpated from the state (Thiel 1993). Despite compiling scattered reports of wolf observations during the 1960s and early 1970s, Thiel (1978) found no evidence of functioning packs in the state.

Recolonization of Wisconsin by wolves began by 1975, and by 1979, five wolf packs were established in two Wisconsin counties. A wolf pack was detected in Minnesota along the Wisconsin border during winter 1974–1975, and between 1975 and 1979, five wolves were found dead in Douglas County, Wisconsin, just east of the Minnesota border (Mech and Nowak 1981; Thiel 1993). Thiel and Welch (1981) documented breeding packs of wolves in the state by 1977 and 1978. In 1979, two wolves were also found dead in Lincoln County, about 200 km southeast of the Douglas County packs (Thiel 1993). The source of colonizing wolves was likely the large Minnesota population to the west, although the appearance of a pack in Lincoln County in north-central Wisconsin in 1979 may indicate that some wolves had persisted in parts of Wisconsin. The Lincoln County pack already consisted of 12 wolves in 1979, indicating that the pack had probably been in the area for ≥2 years.

6.3 Federal and State Endangered and Threatened Listing of Wolves

Because of the decline of gray wolves across the USA, the eastern timber wolf (*Canis lupus lycaon*), defined at the time to include wolves in the western Great Lakes region, was listed as endangered in 1967 on the first list of endangered species promulgated by the US Fish and Wildlife Service (USFWS 1992). Following passage of the federal Endangered Species Act in 1973, the eastern timber wolf was again listed in 1974, and in 1978 all forms of gray wolves were listed as endangered in the contiguous USA, except in Minnesota where wolves were listed as threatened (USFWS 1992).

The Wisconsin Department of Natural Resources (WDNR) also maintained a separate list of state endangered and threatened species, and with their return, gray wolves were listed as endangered species under state law in 1975. In 1979, the WDNR began a program of formal monitoring of the wolf population (Wydeven et al. 1995).

The WDNR developed a state recovery plan in 1989. The plan mandated that wolves would be down-listed to threatened status if the population remained above 80 for ≥3 years consecutively (WDNR 1989). These criteria were also adopted by the USFWS for federal reclassification to threatened status (USFWS 1992). The USFWS also decided that wolves could be removed from the federal list of endangered and threatened species when the population exceeded 100

wolves for ≥5 years in Wisconsin and Michigan, along with a population of 1,251–1,400 wolves in Minnesota (USFWS 1992). These goals were based on late-winter counts when wolves were at the lowest level in their annual population cycle, and were most easily counted from tracks in the snow and observations from the air.

The WDNR developed a state management plan for wolves in 1999. This plan set a state delisting goal of 250 wolves outside of Indian reservations, and a long-term management goal of 350 wolves outside of Indian reservations (WDNR 1999). WDNR goals excluded wolves living on Indian reservations because the state had no management authority for wildlife on Indian reservations. Normally ≤6% of Wisconsin's wolf population occurs on Indian reservations. Under state law, wolves were down-listed to threatened status in 1999 when the statewide count was 205 wolves. Wolves were delisted from state threatened status in 2004 when 335 wolves occurred in the state. Wolves have been classified in Wisconsin as protected wild animals since August 1, 2004. This classification is given to non-game mammals that are not endangered or threatened.

Federal delisting and reclassification has been a more complex and difficult process (Refsnider, this volume). Wolves in Minnesota were down-listed to federal threatened status in 1978, but wolves in Wisconsin and Michigan were still designated as endangered until 2003 when they were classified as threatened as part of the Eastern Distinct Population Segment (Refsnider, this volume). In 2005, wolves in Wisconsin and other states in the Eastern Distinct Population Segment, except Minnesota, reverted back to federal endangered status as a result of lawsuits by environmental and animal welfare groups (Refsnider, this volume). Wolves were removed from the federal list of endangered species in Wisconsin on March 12, 2007, and all management authority for the species reverted to the state.

6.4 Methods for Monitoring Wolves in Wisconsin

6.4.1 Wolf Population Monitoring

Since 1979, we (as WDNR employees) have used a combination of snow-track surveys, aerial radiotracking, summer howling surveys, and collection of observations of wolves to estimate the size of wolf populations annually (Wydeven et al. 1995). We used territory mapping (Fuller et al. 2002) to determine the location of all wolf territories and determine the number of wolves in each territory. Territories were mapped for packs and lone wolves that appeared to occupy regular home range areas, but not for lone wolves that seemed to be dispersing. This survey system likely underestimates lone wolves that occur outside of established territories.

We have live-trapped and radiocollared wolves since 1979, usually during May and June using modified foot-hold traps (Kuehn et al. 1986). Only limited

late-summer trapping was done to avoid capture of bear hounds which are trained or used for bear hunting during that time. Trapping was avoided during fall and winter because of risks of freezing of toes and capturing of hunting dogs. Recently, a few wolves were captured with cable restraints outside of May and June (Olson and Tischaefer 2004). Wolves >14 kg usually were tranquilized with a 5:1 mixture of Ketamine at 0.1 ml/kg and Xylazine at 0.02 ml/kg, and were reversed with Yohimbine at 0.15 mg/kg (Kreeger 2003). Wolf trapping and handling occurs under oversight by the WDNR Animal Care and Use Committee.

Captured wolves were generally fitted with standard VHF radiocollars (Telonics, Mesa Arizona), although a limited number were also fitted with satellite and Global Positioning System (GPS) collars, and some pups were fitted with ear-tag transmitters (Heilhecker et al. in press). Transmitter-equipped wolves were generally located once per week from the air using fixed-wing aircraft, although flights were sometimes more frequent during intense research or less frequent during periods of budget shortfalls. Ground-based telemetry was used for some intense research, and to recover wolves that died. Most transmitters emitted mortality signals after 5.5 or 6 h of inactivity. Year-round radiotracking enabled us to determine annual pack territories. We made special efforts during December–March to observe and count radiocollared wolves and other members of their packs. Radiocollared wolves facilitated aerial observations of packs roughly 30% of the time they were relocated during winter; packs without radiocollared individuals (hereafter non-collared packs) were rarely observed.

We conducted snow-track surveys every winter since 1979–1980 to supplement radio tracking and search new areas for wolf sign. Since 1995, we have used ≥133 survey blocks to provide more systematic coverage of potential wolf range (Wydeven et al. 1996). Each survey block averaged about 500 km^2, and was bordered by highways, public roads, waterways, and state boundaries. Track surveys were focused on areas with historical wolf presence, recent observations of wolves, or areas of highly suitable habitat (Mladenoff et al. 1995, 1999). Northern and central Wisconsin has an extensive network of roads, and all areas used by packs seemed to contain some roads useable by four-wheel drive vehicles. Initially, trained biologists and technicians conducted surveys, but since1995, volunteer trackers have supplemented and enhanced survey coverage. Volunteers were trained in wolf ecology and animal tracking by agency trackers, and agency and volunteer trackers received special training by animal tracker, James Halfpenny (Halfpenny 1986).

Numbers of tracks observed within survey blocks were used to estimate numbers of wolves in non-collared packs. We conducted surveys 1–3 days after new snowfalls, and attempted to cover most snow-covered roads in survey blocks. Trackers located wolf tracks while slowly driving snow-covered roads and trails, or on foot. Observed wolf tracks were followed to determine where they entered and left roads. Discrete packs were determined by distances between track and sign observations, directions of movements, timing of observations, presence of radiocollared packs, historical pack use of an area, and knowledge of focal points such as den sites and rendezvous sites.

6.4.2 Home Range and Territory Mapping

We mapped territories and distribution on non-collared packs by creating polygons that contained all locations of sign and tracks, and reports of observations of wolves within assumed packs. If a pack was collared in the past, we used the previous year's territory area of that pack for current-year area, unless field sign indicated the territory areas had shifted.

The presence of raised-leg urinations (RLUs), especially double RLUs (urinations by both breeding male and female), was used to infer territory marking and likeliness of breeding activity (Peters and Mech 1975). Proestrus and estrus discharges in urine in the snow associated with RLUs of alpha females provided further evidence of breeding activity (Rothman and Mech 1979; Harrington and Asa 2003). Breeding was also determined from observations of heavily trampled areas at copulation sites where copulation ties had occurred (Mech 1970) and observations of excavated den sites. We assumed breeding occurred during most winters in large packs with histories of regular breeding activity.

We used minimum convex polygons to estimate home ranges of radiocollared wolves using ≥ 20 radio locations (Mohr 1947), and this area was assumed to represent the territory of these wolves. Outlier locations >5 km from other locations were considered extra-territorial movements (Fuller 1989), but small clusters (>2) of radio locations greater than 5 km from other locations were assumed to be connected to the main territory area if there were regular movements between the clusters. The annual monitoring period used for wolves was 15 April to 14 April of the following year, and we defined summer as 15 April through 14 September, and winter as 15 September through 14 April.

We estimated the total area of occupied wolf range by summing the current winter territory area for collared packs, the most recent territory area for packs collared within previous three years, and statewide average territory area for non-collared packs. Lone wolves occupying regular territories were also mapped. The total occupied territories were multiplied by 1.37 to include interstitial areas of 37% between pack territories (Fuller et al. 1992), and this total area was assumed to be the occupied range of territorial wolves.

6.4.3 Productivity and Survival

We estimated numbers of pups present during winter from changes in wolf numbers from previous surveys, knowledge of presence of pups from summer howling surveys (Harrington and Mech 1982), reports of observations, and knowledge of pack composition from previously captured wolves. This estimate of pup production might be biased somewhat by sub-adults dispersing into packs, but from our experience in Wisconsin, most such dispersers became members of the breeding pair and would not have been included in the pup count. These methods gave us a

range of estimates of pups present, and we used the midpoint of that range to estimate pup survival. Midpoint estimates of pups present during late winter, numbers of breeding females the previous winter, and a fetal rate of 5.2 fetuses/breeding female (based on placental counts of five adult female wolves found dead in Wisconsin in the 1980s and early 1990s) were used to estimate pup survival from birth to the end of their first winter. Numbers of breeding females the previous winter were determined by assuming one breeding female per pack with evidence of breeding activity. Pup survival was estimated as follows:

$$\hat{S}_{\text{pups}} = \frac{N}{(N_{\text{bf}}\, 5.2)}$$

where $\hat{S}_{\text{pups}}$ = pup survival through their first winter; N = pups alive during the late winter; N_{bf} = estimated number of breeding females the previous winter.

We analyzed the survival of wolves that were radiocollared from 1979 to 2003 using a staggered entry Kaplan-Meier approach (Pollock et al. 1989). We compared the annual survival functions by age (pup, yearling, adult), sex, and by early (pre-1995) and late (post-1994) periods in wolf recovery using log-rank tests (Pollock et al. 1989). Annual survival was estimated using a biological year defined as 1 May through 30 April.

6.5 Population Trends and Ecology of Wolves in Wisconsin

6.5.1 Growth and Expansion of the Wolf Population

We monitored growth of the wolf population in Wisconsin during the winters of 1979–2007 (Table 6.1). Monitoring was facilitated by 2–63 radiocollared wolves (8–37% of the estimated minimum population) that were tracked each winter. The fewest wolves were radio monitored in 1979–1980, the first year of the surveys, and in 1990–1991, when a change of personnel occurred in the wolf-monitoring program. Excluding these anomalies, an average of 27% (±6.6 SD) of the winter wolf population was collared and monitored from 1980 to 1990. This declined to 16% (±4.7 SD) for winters 1991–2007. Overall, a mean of 46% (±14.8 SD) of the packs monitored during 1979–2007 contained at least one radiocollared wolf. The percentage of packs with at least one member radiocollared declined from a mean of 56% (±16.8 SD) during 1980–1990 to a mean of 43% (±6.4 SD) during 1991–2007. In general, the number of radiocollared wolves we tracked each year increased, but the percentage of the wolf population and percentage of packs collared declined as the population increased.

WDNR trackers conducted 760–6,571 km of snow-track surveys annually to estimate number of wolves in non-collared packs, and to supplement wolf counts on collared packs. Volunteer trackers started in 1995, and conducted 526–7,952 km of snow-track surveys annually during the late 1990s and early 2000s. Overall, track surveys increased from 760–1,622 km in the early 1980s when mainly 2 counties

Table 6.1 Efforts associated with Wisconsin's winter survey to estimate the state wolf population sizes (1979–2007)

Winter period	No. of wolves collared	Wolf population collared (%)	Packs collared (%)	DNR snow track surveys (km)	Volunteer track surveys (km)
1979–1980	2	8	20	760	
1980–1981	5	24	40	1,541	
1981–1982	6	22	50	1,622	
1982–1983	7	37	80	1,342	
1983–1984	6	35	75	1,129	
1984–1985	4	27	50	N/A*	
1985–1986	2	13	25	N/A	
1986–1987	5	28	60	N/A	
1987–1988	8	31	66	N/A	
1988–1989	8	26	71	N/A	
1989–1990	8	24	40	N/A	
1990–1991	2	5	17	4,178	
1991–1992	8	18	38	3,957	
1992–1993	10	25	50	6,208	
1993–1994	12	21	50	6,143	
1994–1995	18	22	55	6,253	526
1995–1996	24	24	52	3,447	4,540
1996–1997	22	15	43	3,802	5,341
1997–1998	24	13	43	2,606	4,887
1998–1999	27	13	40	4,457	2,533
1999–2000	32	13	46	3,731	6,347
2000–2001	39	15	43	6,571	5,732
2001–2002	42	13	42	5,428	5,883
2002–2003	63	19	46	4,620	6,094
2003–2004	49	13	35	5,885	7,839
2004–2005	46	11	32	4,466	7,952
2005–2006	43	9	33	4,579	7,884
2006–2007	63	12	40	5,843	6,701

*N/A = data not available.

were surveyed, to 10,000–13,000 km in the 2000s when surveys were conducted in ≥30 Wisconsin counties.

Wolves recolonized extensive areas of northern Wisconsin during 1979–2006 (Fig. 6.1). During the first winter of surveys, we located four packs in Douglas County and one pack in Lincoln County in heavily forested areas of northern Wisconsin (Fig. 6.1a). By winter 1989–1990 we detected 10 pack territories in 8 counties (Fig. 6.1b), and by winter 1994–1995 a total of 22 territories (2 were occupied by lone wolves) were found across 12 Wisconsin counties (Fig. 6.1c).

The first pack of wolves to colonize the Central Forest region (Thiel et al., this volume) was found during winter 1994–1995 about 109 km south of the nearest pack

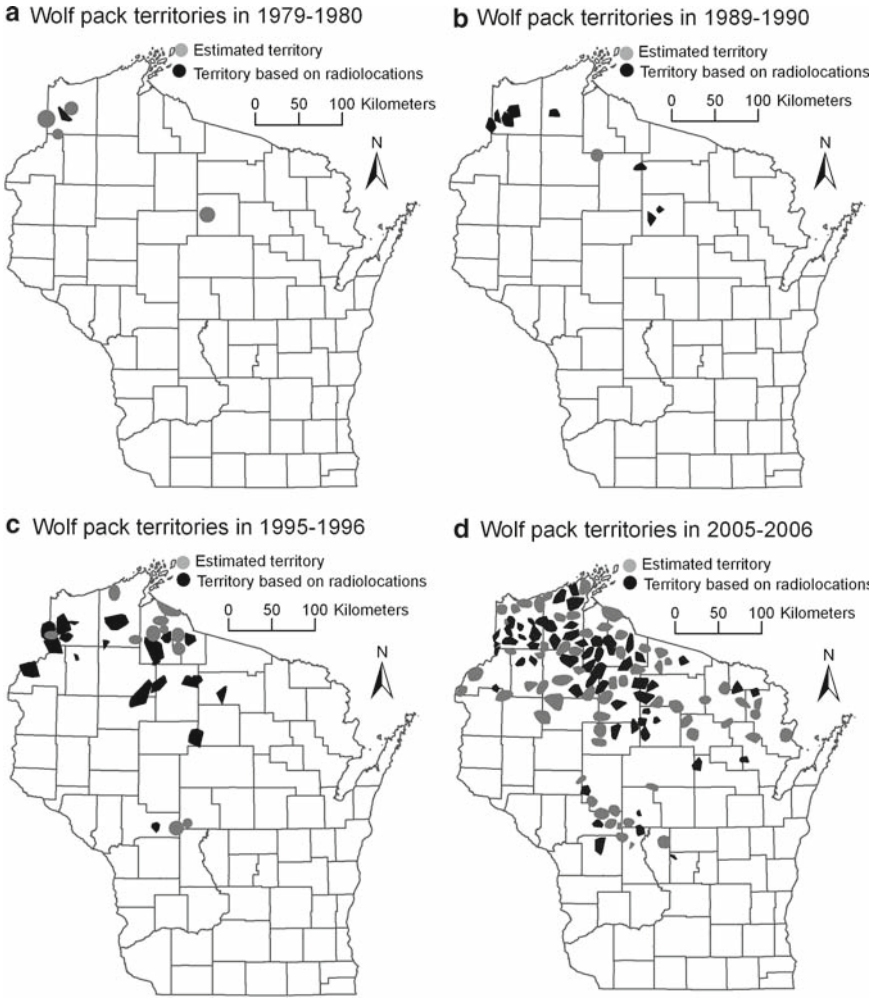

Fig. 6.1 Growth and expansion of the wolf population in Wisconsin for **(a)** 1979–1980, **(b)** 1989–1990, **(c)** 1994–1995, and **(d)** 2005–2006

in the Northern Forest. Wisconsin's Central Forest is an island of extensive forest in the middle of the state and is separated from the Northern Forest region by mostly open farmland. Wolves probably recolonized the Central Forest about 1992 or 1993.

By the early 2000s, wolves had occupied most of the large blocks of public forest land in northwestern and north-central Wisconsin, and wolf packs were beginning to occupy areas of mixed forest and farmland at the southern edge of the northern forests, as well as pockets of agricultural land east of Superior and west of Ashland. By 2005–2006, wolf territories were spread across 31 counties in the Northern and Central Forests (Fig. 6.1d). These territories included at least 116 packs and 5 lone wolves.

6.5.2 Wolf Population Increase and Growth Rates

Our minimum estimate of Wisconsin's wolf population grew from 25–28 wolves in 1979–1980 to 540–577 wolves in winter 2006–2007 (Table 6.2). The wolf population declined to 14–16 wolves in 1984–1985, apparently due to high mortality associated with canine parvovirus (Wydeven et al. 1995). After 1985, the population grew to 34 by 1990 (annual growth [λ] = 1.18). Between 1990 and 2000, the wolf population grew at a rapid annual rate (λ = 1.22), but annual growth rate declined to λ = 1.12

Table 6.2 Estimated characteristics of the wolf population during winter in Wisconsin (1980–2007)

Year	Estimated wolf population	Packs	Mean pack size ± SD	Largest pack	Loners detected	Loners (%)	Area occupied by wolf territories (km^2)	Wolf density per 1,000 km^2
1980	25–28	5	5.0 ± 4.0	12	0?	0?	1,469	17.0
1981	20–24	5	4.0 ± 2.4	7	0?	0?	1,752	12.0
1982	23–27	4	5.2 ± 2.5	9	2	9	1,310	20.6
1983	19–20	5	3.4 ± 1.3	5	2+	11	1,752	10.8
1984	18–19	4	4.0 ± 2.8	8	2+	11	1,352	12.6
1985	14–16	4	3.3 ± 2.5	7	1	7	963	15.5
1986	15	5	2.6 ± 0.9	4	2	13	1,504	10.6
1987	18–20	5	3.2 ± 1.8	6	2	11	1,188	15.2
1988	26–27	6	3.8 ± 1.2	6	3+	12	1,243	22.5
1989	31	7	4.0 ± 1.8	6	3	10	1,756	17.7
1990	34	10	3.1 ± 1.4	5	3	9	2,799	12.1
1991	39–41	12	3.1 ± 1.0	5	2	5	2,874	13.9
1992	45–52	13	3.0 ± 1.4	5	6	13	2,235	20.1
1993	40–42	12	2.8 ± 0.8	4	6	15	1,909	21.0
1994	54–61	16	3.1 ± 1.3	6	5	9	3,367	16.9
1995	83–86	21	3.6 ± 1.7	8	9+	11	4,299	19.3
1996	99–105	31	3.1 ± 1.3	7	3	3	6,255	15.8
1997	148–151	35	4.1 ± 2.1	10	5	3	5,698	26.0
1998	178–184	47	3.7 ± 1.5	8	6	3	8,547	20.8
1999	205–211	57	3.5 ± 1.6	8	7	3	8,856	23.1
2000	248–259	66	3.6 ± 1.9	11	13+	5	9,301	26.6
2001	257–259	70	3.6 ± 1.5	9	7	3	9,013	28.5
2002	327–343	83	3.8 ± 1.9	10	8+	2	12,986	24.8
2003	335–353	94	3.4 ± 1.5	8	12	4	15,644	21.0
2004	373–410	108	3.2 ± 1.4	9	14	4	13,367	29.7
2005	435–465	113	3.7 ± 1.8	9	14+	3	16,506	27.2
2006	467–504	116	3.9 ± 1.8	12	13	3	14,116	34.8
2007	540–577	138	3.8 ± 1.7	9	17	3	15,869	35.5

between 2000 and 2007, suggesting that habitat was becoming saturated (Van Deelen, this volume). A minor decline occurred in 1993, 2 years after sarcoptic mange was first identified. However, the decline was also linked to two small packs shifting their territories into adjacent states. Minor levels of mange persisted in Wisconsin wolves during the later 1990s and early 2000s without impacting population growth.

6.5.3 Pack Size and Territory Size

We detected 4–138 wolf packs across Wisconsin during winter surveys (Table 6.2). Mean pack sizes ranged from 2.6 to 5.2 wolves annually. Packs were relatively larger during early years (a bias produced by a few large packs), and lowest during population declines. Recently, mean pack size was 3.2–4.1 wolves per pack. The largest packs observed in the state each year declined during the mid-1980s and early 1990s, but increased in the late 1990s and 2000s. During the 28 years of surveys, packs of ≥10 wolves were detected in only 5 years, and only occurred during 1 year when <148 wolves were found in the state.

Mean size of wolf pack territories evidently declined as wolves increased in Wisconsin (Fig. 6.2). The annual mean territory size was determined for 2–36 pack territories for which ≥20 radio locations were obtained. Prior to 1993, the annual mean territory size was based on less than 7 packs annually, and often only 2–3 packs. Since 1999, annual territory size was based on ≥21 pack areas. Mean pack

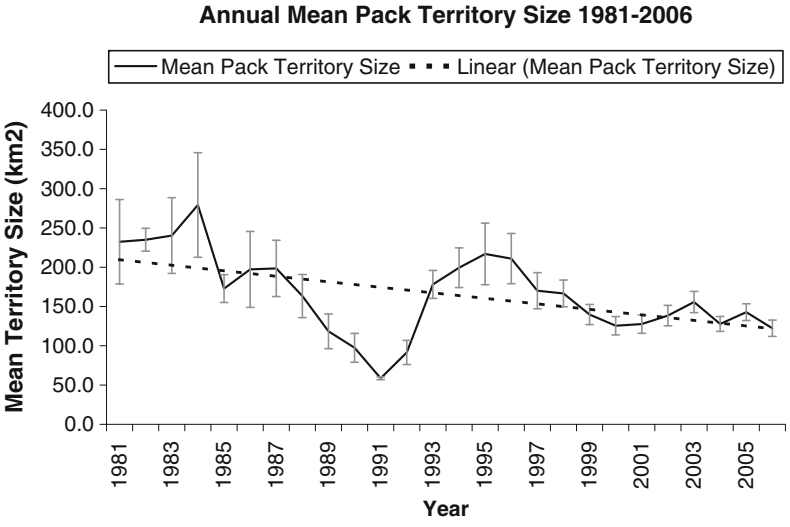

Fig. 6.2 Annual mean size of wolf territories in Wisconsin from 1981 through 2006, and standard errors of mean pack areas

territory size seemingly declined from 180 km^2 (±85 SD) in 1981–1990 to 165 km^2 (±94 SD) in 1991–2000, and was down to 136 km^2 (±67 SD) in 2001–2006. The apparent decline in the early 1990s in Fig. 6.2 may be an artifact of the small number of packs (2 or 3) with relatively small territories being sampled those years.

6.5.4 Lone Wolves

The percentage of the wolf population we detected as lone wolves ranged from 0% to 15% (mean 6.5% ± 4.3 SD). The percentage of the population detected as loners was higher between 1981 and 1995, with ≥83 wolves detected in the state (mean 9.7% ± 3.5 SD), than during the period 1996–2007, with ≥99 wolves in the state (mean 3.2% ± 0.7 SD). We probably routinely underestimated lone wolves because wolf surveys were focused on wolves living in territories.

6.5.5 Production of Pups and Survival

Our estimated numbers of wolf pups ranged from a low of 3 pups during winter 1985–1986 to 190 during winter 2006–2007 (Table 6.3). Estimated survival of pups ranged from 14% to 58%, with a mean of 29.4% (±8.6 SD). Lowest survival of pups occurred during the mid-1980s, coincident with an outbreak of parvovirus (Wydeven et al. 1995), and in 1993, when sarcoptic mange seemed to be having some impacts on survival. Highest survival of pups occurred during the early stages of wolf recolonization, when a few packs had very high pup survival. Although mean survival of pups was similar during 1979–1990 (29.7% ± 12.4 SD) and 1990–2007 (29.1% ± 4.9 SD), survival of pups was more variable during early colonization.

An average of 32.2% of packs (±15.8 SD) had no surviving pups detected during late winter (range: 0–75%). During the first 11 years of surveys, a mean of 36.5% (±22.9 SD) of packs had no surviving pups, but during the last 17 years a mean of 29.4% (±7.3 SD) of packs had no surviving pups detected and annual fluctuations were less variable.

Radiotracking between 1979 and 2003 resulted in 445, 163, and 84 wolf-years of telemetry records for adults, yearlings, and pups, respectively. The survival of radio-collarred wolves was remarkably consistent across sex and age classes and between age class estimates for early and late periods of wolf recovery. Survival functions did not differ by sex for adults ($X^2_1 = 0.51$, $P = 0.48$), yearlings ($X^2_1 = 0.13$, $P = 0.71$), or pups ($X^2_1 = 1.15$, $P = 0.28$). With sexes pooled, survival functions did not differ in pairwise comparisons of age class (adult vs yearling: $X^2_1 = 0.06$, $P = 0.80$; adult vs pup: $X^2_1 = 0.12$, $P = 0.73$; yearling vs pup: $X^2_1 = 0.18$, $P = 0.67$). In addition, survival did not differ between early and late recovery for adults ($X^2_1 = 0.66$, $P = 0.41$), yearlings ($X^2_1 = 0.03$, $P = 0.86$), or pups ($X^2_1 = 0.93$, $P = 0.33$). Survival rates were 0.75 (95% confidence interval [CI]: 0.69–0.79) for adults, 0.75 (CI: 0.59–0.89) for yearlings,

Table 6.3 Estimated numbers and survival of wolf pups in Wisconsin (1979–2007)

Winter period	Estimated number of pups in winter	Midpoint of pup estimates	Estimate of pup survival (%)	Packs with no surviving pups (%)
1979–1980	10–15	12	58	0
1980–1981	6–8	7	34	25
1981–1982	7–11	9	43	0
1982–1983	3–7	5	24	25
1983–1984	5–7	6	38	33
1984–1985	3–5	4	19	75
1985–1986	3	3	14	50
1986–1987	5–8	6	19	67
1987–1988	8–10	9	29	33
1988–1989	11	11	30	43
1989–1990	6–10	8	19	50
1990–1991	11–15	13	23	27
1991–1992	10–16	13	25	50
1992–1993	10	10	19	30
1993–1994	12–20	16	24	38
1994–1995	24–28	26	33	27
1995–1996	29–34	31	30	25
1996–1997	56–66	61	40	24
1997–1998	60–72	66	33	24
1998–1999	58–78	68	28	29
1999–2000	77–98	88	31	37
2000–2001	74–101	88	28	30
2001–2002	89–151	120	34	19
2002–2003	92–129	110	26	30
2003–2004	105–150	128	26	33
2004–2005	118–192	155	31	25
2005–2006	151–222	186	32	19
2006–2007	148–232	190	32	34

and 0.72 (CI: 0.51–0.94) for pups. Survival rates of pups represent survival to the end of a wolf-year for pups captured in late summer or early fall at 3–6 months of age, and thus are much higher than the indirect method used above. Survival functions indicated relatively steady mortality rates over time (Fig. 6.3).

6.6 The Wisconsin Wolf Management Plan

Primary authority for wolf management in Wisconsin returned to the WDNR on March 12, 2007 when wolves were removed from the federal list of endangered and threatened species. The 1999 Wisconsin wolf management plan (WDNR 1999) and

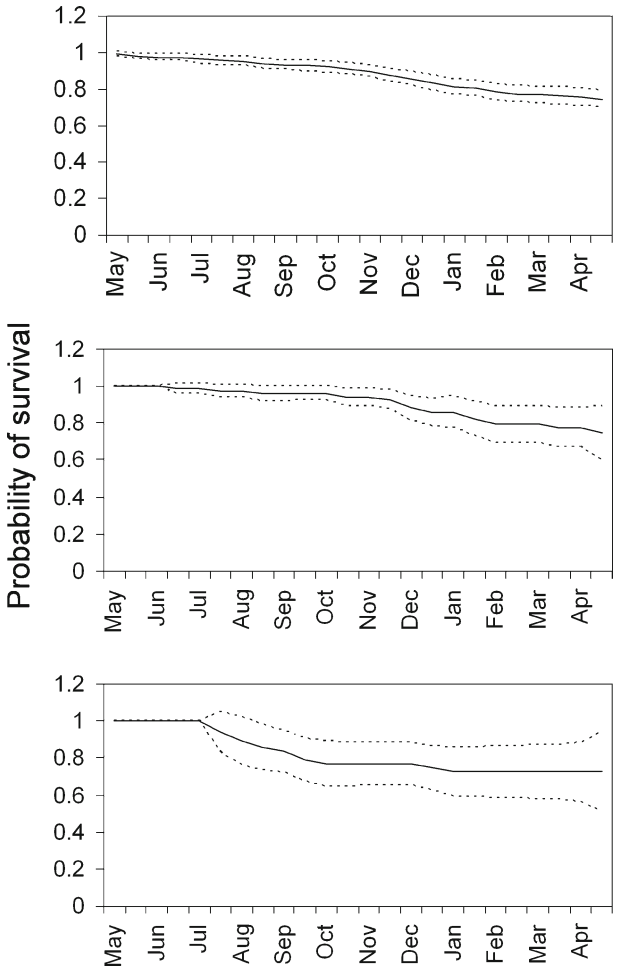

Fig. 6.3 Kaplan-Meier survival functions for wolves radiocollared in Wisconsin 1979–2003, showing adults (top), yearlings (middle), and pups (bottom)

its updates subsequently direct wolf management in the state. Between 1980 and 2007, the wolf population in Wisconsin grew beyond all the listing and management goals set for the population (Fig. 6.4).

A goal of Wisconsin's wolf management plan is maintenance of a viable and healthy population of wolves while attempting to minimize wolf depredation problems. The plan allowed more progressive control as the wolf population was down-listed from endangered to threatened to a delisted, protected wild animal under state law. When wolves attained threatened status (>80 wolves for ≥3 years), reactive lethal control by government trappers was allowed for wolves verified as depredators on domestic animals on private lands. When wolves met the criteria for state delisting (>250 outside Indian reservations), landowner control of problem

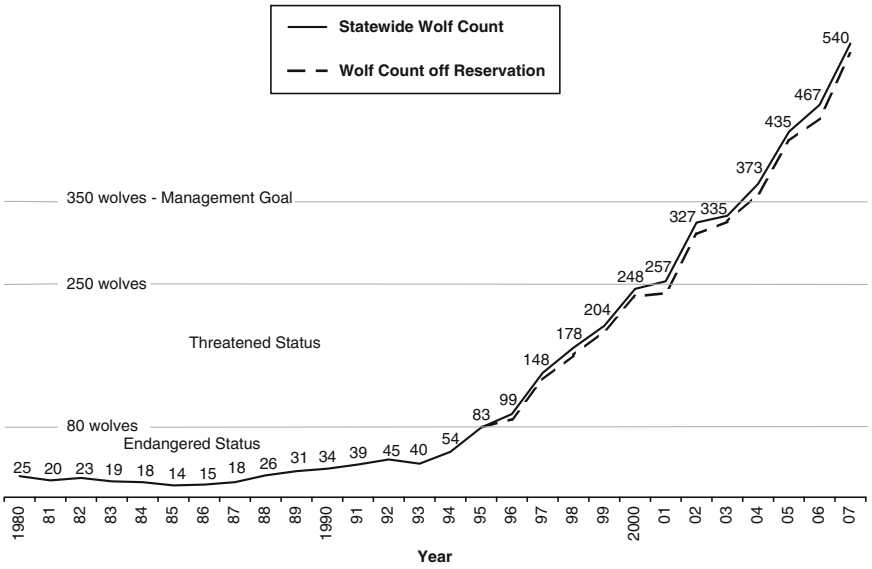

Fig. 6.4 Growth of the Wisconsin wolf population as represented by minimum counts in late winter statewide, and outside of Indian reservations. The state management designations for the wolf population at different sizes for areas outside of Indian reservations are listed

wolves could be authorized. When wolf numbers exceeded the population goal (>350 outside Indian reservations), proactive control by government trappers could occur, and a public hunting or trapping season could be considered. Wisconsin's current wolf management goal of 350 wolves was set at a time when there were <205 wolves in the state, and it was assumed to roughly represent the level of social acceptance of wolves. The population goal will be reexamined periodically to accommodate changing understanding of the interaction between wolf life history and human acceptance.

Although Wisconsin's wolf management plan allowed progressive levels of lethal control, many of these controls were not possible until federal delisting occurred. Limited lethal control was authorized for Wisconsin by the federal government in 2003–2006 to control wolves depredating domestic animals on private land, but it was not until federal delisting occurred in 2007 that the state was able to fully implement its management plan.

Mladenoff et al. (1997) estimated the potential equilibrium wolf population for Wisconsin using habitat area and prey-based models. Their estimate of potential wolf numbers based on habitat analysis was 380 (90% confidence interval [CI]: 324–461), and their estimate by the prey-based model was 462 (90% CI: 262–662). Consequently, WDNR used a population of 500 wolves as the estimated potential biological carrying capacity of the state. Although the wolf population in Wisconsin exceeded this number in 2007, recent declines in rate of growth suggest the wolf population may be approaching an equilibrium level (Van Deelen, this volume).

The WDNR management goal was set lower than the biological carrying capacity because managers assumed that acceptance by humans (social carrying capacity) would be less than the biological potential. Numerous livestock depredations during 2004–2006 suggested that a population of 373–467 wolves already exceeded the social carrying capacity for some stakeholders (Wydeven et al., in press; Ruid et al., this volume).

Wisconsin's wolf management plan includes four wolf management zones (Fig. 6.5, Wisconsin DNR 1999). Zones allow for maximum levels of wolf protection in areas with most suitable habitat, but allow more freedom to control problem wolves in areas of marginal or poor habitat. In 2007, Zone 1 contained 81% of the wolves in the state, Zone 2 had 13%, Zone 3 had 6%, and Zone 4 had <1%. Zones 1 and 2 represent large, forested, and wildland areas in large blocks of public land where

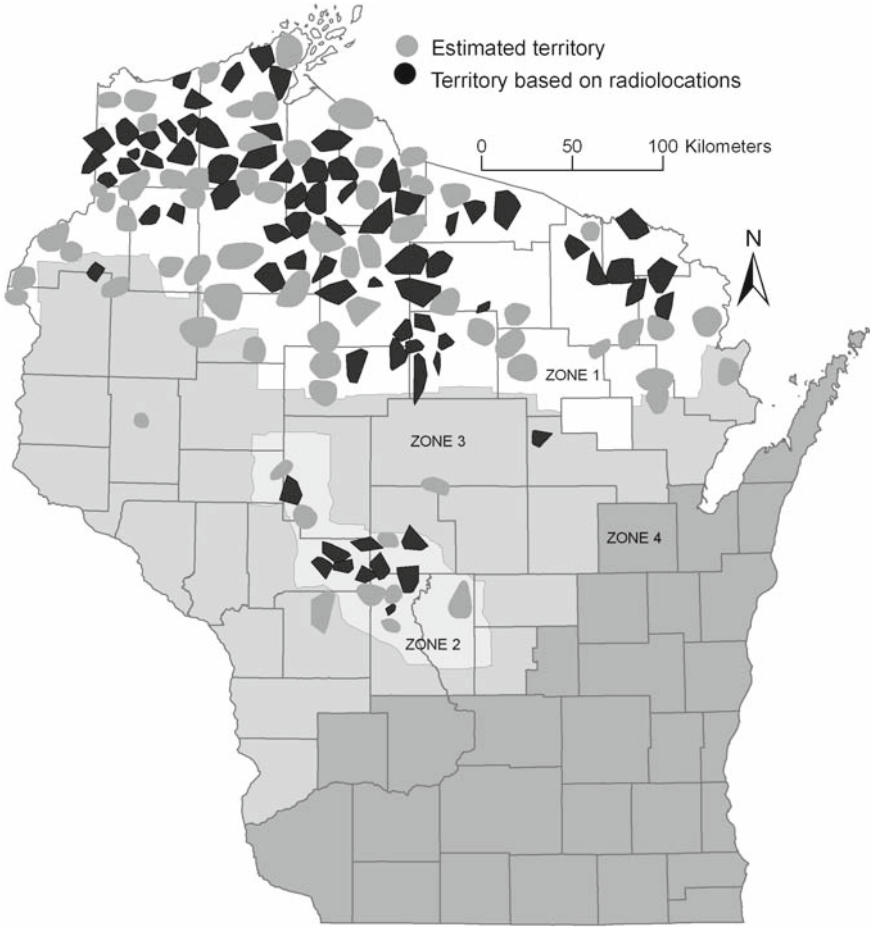

Fig. 6.5 Wolf management zones in Wisconsin with the distribution of wolf territories in 2007 illustrated. Wolf conservation activities are concentrated in Zones 1 and 2

wolf conservation activity is focused. Within these two zones, den sites are protected, and public land agencies are encouraged to maintain forests with low road densities and provide adequate habitat for prey (deer and beavers). Reactive depredation control activities are focused within 1.6 km of depredation sites. Proactive control by government trappers will focus on pockets of agricultural land or areas of high interspersion of forest and farmland where livestock depredations are likely (Treves et al. 2004). Zone 3 represents marginal wolf habitat, and habitat management will focus mainly on maintaining adequate areas of forest cover to allow dispersing wolves to travel between Zones 1 and 2. Reactive depredation control activities are allowed up to 8 km from depredation sites, and liberal use of proactive control will be used on problem wolves. Zone 4 represents areas of poor wolf habitat, and liberal control will be applied to any problem wolves that enter the zone.

6.7 Future of Wisconsin's Wolf Population

Under the guidelines of the WDNR management plan, the wolf population in Wisconsin is expected to begin to stabilize (assuming lawsuits do not cause wolves to be relisted by the federal government), and should decline in areas of mixed forest and farmland that would be considered marginally suitable wolf habitat. The wolf population should continue to spread into northeastern Wisconsin, and eventually saturate most areas of suitable habitat in the area. Wolf populations will mostly be allowed to fluctuate naturally with prey populations within areas of public forest in northern and central Wisconsin. In agricultural areas, wolf depredations will be controlled through trapping and shooting by government trappers, and shooting permits for landowners; these controls are likely to have a dampening effect on wolf populations in agricultural regions. The Central Forest wolf population may eventually become more isolated by increased human developments and traffic. Overall, suitable habitat may also decline in northern Wisconsin due to extensive development of secondary homes in forests, especially in areas near lakes (Radeloff et al. 2005).

6.8 Summary

Wolves were abundant in Wisconsin when European settlement began in the 1830s, but were extirpated by 1960 due to human attitudes and bounties. Wolves returned to Wisconsin about 1975, and the WDNR began a population-monitoring program in 1979. The late-winter wolf population grew from 25 wolves in 1979–1980 to 540 wolves in 2006–2007. During this period the range occupied by territorial wolves grew from <1,500 km^2 to >14,000 km^2. Mean pack size has generally averaged slightly less than 4, survival rates of pups to the end of the first winter averaged 29%, and about 32% of packs were unsuccessful raising pups. The Wisconsin

management plan includes a population goal of 350 wolves outside of Indian reservations, and uses a zone system as well as landowner and government control to manage the population toward this goal.

Despite Wisconsin's reputation as an agricultural and heavily populated state, wolves have been able to successfully return after extirpation in the 1950s. This successful recovery was possible because of adequate habitat in portions of the state, a high prey base, proximity to a large source population, public education and changing public attitudes toward wolves, and adequate legal protection by federal, state, and tribal agencies. The wolf population is relatively secure in the state for the foreseeable future, but continued human developments and human population growth are likely threats. Intense population monitoring and protection of habitat will need to continue to assure that wolves remain secure in Wisconsin.

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