Chapter 7
A Disjunct Gray Wolf Population in Central Wisconsin

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7.1 Introduction

Wisconsin's Central Forest Region (CFR) is a 7,155-km^2 L-shaped area in west-central Wisconsin extending from Chippewa Falls and Eau Claire to Tomah, Adams-Friendship, and Wisconsin Rapids (Fig. 7.1; Curtis 1959; Finley 1976). The CFR lies within the unglaciated driftless area and consists of flat, sandy, late Pleistocene glacial lake sediments and occasional Cambrian sandstone or Precambrian igneous outliers. Extreme western portions of the CFR consist of ridges and deeply incised valleys of Cambrian sandstones (Martin 1965; Schultz 1985). This region was logged between 1850 and 1920. In the past century its marshes were drained, its uplands and lowlands farmed, and much of it was abandoned by the time of the Great Depression of the 1930s (Grange 1948).

Humans sparsely inhabit the CFR. Economic activities are mainly forestry, outdoor recreation, and cranberry (*Vaccinium*) agriculture. The region consists of forests of oak (*Quercus*), aspen (*Populus*), pine (*Pinus*) and a variety of wetlands ranging from tamarack (*Larix laracina*) and black spruce (*Picea mariana*) swamps to sedge and sphagnum bogs. Floristically, the CFR resembles the northern forested region of Wisconsin, but is isolated from it by a 22–72-km wide zone of intense agriculture (primarily dairy, grain, and forage crops). About 2,574 km^2 in the central CFR is publicly owned, consisting of a mixture of county forests (Adams, Clark, Eau Claire, Jackson, Juneau, Monroe, and Wood counties), state forests (Black River State Forest and several Wildlife Areas,) and federal properties (Necedah National Wildlife Refuge, Meadow Valley State Wildlife Area, Fort McCoy Military Reservation). These forests primarily are managed for forestry, recreation, and wildlife conservation.

Gray wolves (*Canis lupus*) ranged throughout the CFR prior to European settlement and were probably extirpated as a breeding population by 1920 (Thiel 1993). Some dubious bounty data and local accounts suggested that individual wolves may have survived within the CFR until the 1950s when the species disappeared from all of Wisconsin.

Initially wolves recolonized several small, isolated areas within northwestern and north-central Wisconsin during the mid- to late-1970s (Mech and Nowak 1981;

A.P. Wydeven et al. (eds.), *Recovery of Gray Wolves in the Great Lakes Region of the United States*,
DOI: 10.1007/978-0-387-85952-1_7,

The original version of this chapter was revised: The book was inadvertently published with corrections in several chapters of this book. This has been corrected in the affected chapters.
A correction of this chapter can be found at DOI 10.1007/978-0-387-85952-1_22.

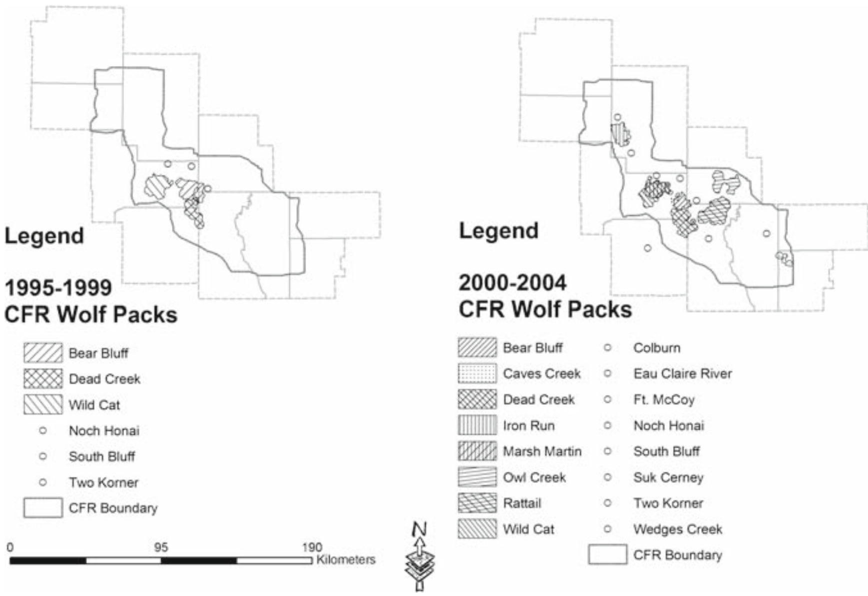

Fig. 7.1 Map of pack distribution in the Central Forest Region (*CFR*) in 1995–1999 and 2000–2004

Thiel and Welch 1981; Thiel 1993; Wydeven et al. 1995). By 1990, wolves began expanding their range in Wisconsin (Wydeven et al. 1995). Citizens' reports of large canids in CFR surfaced in 1992. In November 1994, a radiocollared yearling male wolf was killed near Oakdale on Interstate Highway 90/94 just south of the CFR. Surveys and monitoring for gray wolves began during winter 1994–1995 in the CFR. This chapter summarizes monitoring of gray wolves in the CFR between the winter of 1994–1995 and 2005–2006. We also address concerns for the long-term maintenance of the CFR wolf population because of its geographic separation from the larger Lake Superior basin wolf population located further north.

7.2 Methods for Monitoring Wolves in Wisconsin's CFR

As employees of Wisconsin's Department of Natural Resources (WDNR), we maintained records of citizen and staff reports of wolf sightings and tracks. Initially, we tried to confirm presence by searching areas of sightings after snowfall. Following discovery of wolves, department staff and cooperators from other agencies (United States [US] Fish and Wildlife Service, Ft. McCoy Military Reservation, Jackson and Wood County Forestry, and the Ho-Chunk Nation's Department of Natural Resources) and trained volunteers conducted winter-track surveys annually to count wolves throughout the CFR.

Wolves were captured in foot-hold traps from May through mid-September, or radioed when coyote trappers accidentally captured wolves during autumn and winter trapping. Methods for sedating, handling and radiocollaring, and aerially locating CFR wolves are described by Wydeven et al. (this volume). Additional information came from a study of mortality of wolf pups outfitted with ear-tag radio transmitters (Heilhecker et al. in press).

We determined number of packs, number of wolves per pack, and total population size in the CFR through aerial observations of wolves accompanying radioed individuals, and by counting tracks while conducting winter-track surveys annually (Wydeven et al. 1995; Thiel and Welch 1981). We defined a pack as a group of ≥2 wolves. Dispersal and mortality data are limited to CFR wolves radiocollared between 1995 and 2004.

We used the minimum convex polygon and fixed kernel methods to determine the sizes of wolf pack territories in the CFR (Millspaugh and Marzluff 2001). Road densities (RDs) were calculated within pack territories using criteria described by Mladenoff et al. (1995, 1999). Wydeven et al. (2001) found that RDs were related to human-caused mortalities. The lowest RDs in CFR are above the 0.45 km/km^2 threshold used by Mladenoff et al. (1995, 1999) to separate suitable from nonsuitable habitat for wolves. We tested whether pack sizes differed and whether rates of human-caused mortality were positively associated with RD for CFR packs inhabiting the lowest RD, or "core" habitat areas ($RD < 0.80$ km/km^2), and relative to wolves inhabiting higher RD, or "marginal" habitat areas ($RD > 0.79$ km/km^2). Wolf population density was estimated by dividing the sum of the numbers of wolves observed in winter in radioed packs by the summed sizes of their respective pack territories (Fuller et al. 2003).

We recovered dead wolves and transported them to the US Geological Survey Wildlife Health Center or the WDNR Wildlife Health lab for necropsy to determine cause of death. For incomplete diagnostic cases we relied on field evidence to estimate cause of death. Mortality information was based on two classifications of dead wolves: radioed individuals and all recovered animals. Radioed wolves provided the least biased determination of mortality, whereas all recoveries provided evidence of the breadth of the more minor causes of death among wolves. Annual survival rates were calculated from radioed wolves following Heisey and Fuller (1985).

We conducted howl surveys annually between June and September to estimate numbers of CFR packs that produced pups (Fuller and Sampson 1988; Harrington and Mech 1982; Wydeven et al. this volume). Lack of response from pups in surveyed packs cannot be interpreted as an absence of pups. Therefore, percent of packs with pups detected represents a minimum estimate.

Seasons were defined as winter: December–February; spring: March–May; summer: June–August; and fall: September–November.

7.3 Population Trends and Ecology of CFR Wolves

Founder wolves probably arrived in the CFR by 1992–1993. During winter 1994–1995, track surveys detected ten CFR wolves, organized as one reproductive pair and a pup, three colonizing pairs, and one single wolf (Thiel et al. 1997). An additional pair of wolves was likely present but was not found until the following winter.Thus, the CFR wolf population consisted of 12 wolves in 1994–1995.

Between 1995 and 2004 we accumulated 2,798 trap nights and captured 54 wolves, including 18 pups captured as part of a discrete study of mortality of wolf pups conducted in collaboration with the University of Wisconsin-Stevens Point (UWSP, Heilhecker et al. in press). Our combined capture rate was 52 trap nights per wolf. We radiocollared 12 females (15 total captures of 2 pups, 4 yearlings, and 6 adults) and 18 males (19 total captures of 6 pups, 3 yearlings, and 9 adults). Our data consisted of 15,253 radio days from radiocollared wolves and 1,359 radio days from ear-transmittered pups.

Wolves rapidly colonized the CFR, expanding to >50 wolves in 16 packs by 2003–2004 (Fig. 7.1; Table 7.1).The observed mean annual finite rate of increase during the 9-year period was 1.22. The annual survival rate of radiocollared wolves, excluding animals in the UWSP pup study, was 0.73 (CI: 0.62–0.89, n = 15,252 transmitter days).

Territory sizes of radioed wolf packs averaged 144 km^2 and varied from 71 to 233 km^2. Territory size was relatively stable over the years. We calculated a density of 24 wolves/1,000 km from eight radioed wolf packs monitored between 2000 and 2004.

Three population pulses were evident between 1994–1995 and 2005–2006 as the CFR wolf population expanded and dispersers established additional territories (Table 7.1). Mean pack size when more than one new territory was detected annually was 3.1 wolves/pack versus 4.2 wolves/pack when less than two new territories were detected annually. This pattern was related to varying numbers of founding pairs as colonization proceeded.

We estimated that litter size at birth was about seven pups based on placental scars from necropsies of four adult CFR females. The average observed litter size during summer was 4.8 pups (n = 9; range 3–6 during 7 pack-years). Howling surveys to detect presence of pups in CFR packs during summer months indicated that pups were present in an average of 72% of packs surveyed each year (range: 57–89%) from 1996 to 2004.

Six of 16 ear-transmittered pups (37%) died during surveillance between July 15 and January 15 in 2002 and 2003. Five died between 91 and 143 days of age from

Table 7.1 Population trends of wolves in the Central Forest Region (CFR) of Wisconsin, 1994–1995 through 2005–2006

Year	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
No. of packs	4	4	5	8	9	9	9	13	14	16	14	14
No. of wolves	12	18	27	27	29	44	37	35	41–45	52–53	48–50	54–57
Mean pack size	3.0	4.5	5.4	3.4	3.2	4.9	4.1	2.7	3.0	3.3	3.5	4.0

a combination of mange and severe emaciation. One of these was also diagnosed with canine distemper. Four of the mortalities were members of a single litter born in 2002, and a fifth was from a litter born in 2003. A sixth pup was shot illegally by a deer hunter at ~224 days of age. The 6-month mortality rate of the ear-tag-transmittered pups, (ages 3–9 months), was 0.20 (95% CI: 0.05–0.72).

Between 1999 and 2004, 33 dead CFR wolves were recovered. Twenty of these were radiocollared, of which 13 had functional radios at the time of death. Age was determined for 29 individuals and included 12 pups (41%), 2 yearlings (7%), and 15 adults (52%). Seasonal distribution was 6 deaths during spring (18%), 7 during summer (21%), 13 during autumn (40%), and 7 during winter (21%).

Fifty-three percent of the radiocollared subsample and 55% of all recovered wolves were killed by humans (e.g., gunshot, vehicle collisions) followed by 23% of radioed and 18% of all wolves, respectively, dying from disease/parasitism (Fig. 7.2). One radioed wolf was euthanized after Department of Natural Resources (DNR) officials received reports of a wolf dragging its hind legs along a state highway. Necropsy was inconclusive, but this wolf had not been hit by a vehicle as we suspected.

Between 1996 and 2006, 52 complaints of gray wolf-livestock depredations, pet attacks, and nuisance wolves were reported within the CFR. Fourteen (27%) of these complaints were caused by wolves. Coyotes (25%), dogs (11%), and other causes (29%, includes still-births, car-killed livestock or pets, etc.) predominated. Wolves depredated two calves at a single farm, killed or injured seven dogs, and

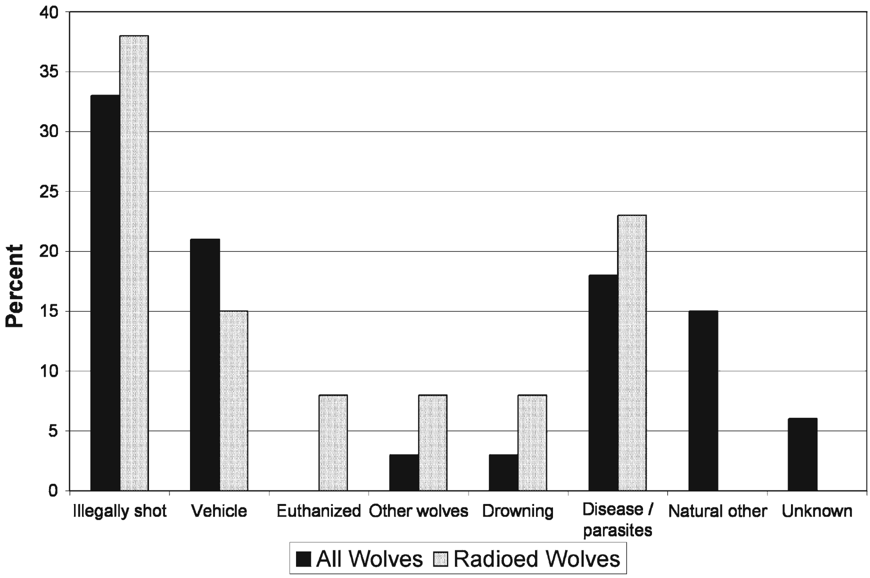

Fig. 7.2 Causes of death for radio-equipped wolves (n = 20) and all wolves (n = 33) recovered in the Central Forest Region (*CFR*) of Wisconsin, 1999–2004. Radio-equipped wolves are a subset of all wolves

were responsible for five cases exhibiting human-habituated behaviors or threatening domestic animals.

Twelve radiocollared (6 males, 6 females) and 3 ear-transmittered wolves (1 male, 2 females) dispersed. One female made 2 predispersal movements at 16 and 20 months of age prior to dispersing at 28 months. Likewise 2 males made single predispersal forays at 31 and >94 months before dispersing at 42 and >128 months, respectively. Males tended to disperse at an older age (mean = 51 months; range:11–128 months) than females (mean = 20 months; range: 9–31 months, $P = 0.07$), although this is mostly due to a male that dispersed at >128 months.

Dispersal times, measured as the number of days between leaving a territory to settling into a new territory, did not differ between males (mean = 67 days; range: 1–127 days) and females (mean = 44 days; range: 1–109 days, $P = 0.29$). Dispersing males traveled an average of 186 km (range: 124–312 km), whereas females covered 104 km (range: 99–117 km, $P = 0.56$). Straight-line distances between the centers of vacated territories and new territories colonized or integrated into, or sites of death prior to settlement did not differ for males (mean = 83 km; range 22–288 km) and females (mean = 67 km; range: 50–82 km, $P = 0.67$).

Five dispersers (4 males, 1 female) successfully colonized new territories. One dispersing male and 4 dispersing females integrated into existing pack territories. Seven of the 12 dispersers (3 males, 4 females, 58%) were known or suspected to have reproduced. Eight (3 males, 5 females) settled within the CFR.

Five radioed wolves (four males, one female) dispersed out of the CFR. Two males and a female dispersed north-northeast between 42 and 288 km. The greatest northerly distance was traveled by male wolf 307 who disappeared on March 28, 2000 and whose skull and radiocollar were found near L'Anse, Michigan, during spring 2007. Two males dispersed south-southeast distances of 119 and 689 km. The greatest southerly distance traveled was of a male pup 409, who left its natal territory sometime after January 15, 2003. Its carcass was recovered 19 km west of the Ohio/Indiana state line on June 20, 2003, having moved 689 km within 6 months (Heilhecker et al. in press).

Wolves from other populations dispersed into the CFR as well. A yearling male wolf radiocollared in Lincoln County, Wisconsin, was killed by a car 10 km south of the CFR in November 1994. A radiocollared female wolf pup dispersed from its Gogebic County, Michigan, pack after December 20, 1999 and was found shot on January 15, 2000, ~15 km northeast of CFR, having dispersed 173 km in a 37-day period.

7.4 Discussion

Analysis of habitat preferences of radioed wolves in northwestern Wisconsin classified wolf habitat within the northern half of Wisconsin, upper Michigan, and northern Minnesota (Mladenoff et al. 1995, 1999). The best landscape filter for identifying wolf habitat used RDs with a threshold of <0.45 km/km^2 corresponding to a >0.50 probability of wolf occupancy (Mladenoff et al. 1995, 1999). One outlier of potentially favorable wolf habitat identified in Mladenoff et al.'s (1995, 1999) analysis was Wisconsin's CFR, considered wolf habitat despite its small size and marginally suitable RDs (RDs >0.45 km/km^2). The CFR is separated from the more extensive contiguous forest region of northern Wisconsin, Michigan's Upper Peninsula, and Minnesota by a 22–72-km swath of intensive agriculture and a buffer of surrounding forest–farm mix that is considered marginal wolf habitat (Wisconsin DNR 1999).

The CFR wolf population increased from 12 wolves in 4 packs to more than 50 wolves in 16 packs within 9 years (Table 7.1). The high annual finite rate of increase of 1.22 exhibited by the CFR wolf population is typical of growth rates observed in naturally colonizing populations studied in northwestern Minnesota and in northern Wisconsin (Fritts and Mech 1981; Wydeven et al. 1995, this volume; Van Deelen this volume), and by populations recovering from intensive experimental control actions (Ballard et al. 1987; Hayes and Harestad 2000; Fuller et al. 2003).

Pack territory size is usually larger in colonizing populations relative to established or saturated populations (Fritts and Mech 1981; Hayes and Harestad 2000; Mech and Boitani 2003). Territory sizes of CFR packs ranged from 71 to 233 km^2, and averaged 144 km^2, smaller than most reported wolf territories where primary prey are white-tailed deer (e.g., 116–344 km^2; Fuller et al. 2003). Territories of CFR wolves were also smaller than mean territory sizes (179 km^2; range 47–179 km^2) observed in a recolonizing population of wolves studied in northern Wisconsin between 1980 and 1990 (Wydeven et al. 1995).

Wydeven et al. (1995) observed an inverse relationship between sizes of wolf pack territories and white-tailed deer density. Densities of deer in CFR were higher (10–19 deer/km^2) than those observed by Wydeven et al. (1995). The smaller territory sizes for CFR wolf packs are consistent with observations of an inverse relationship between territory size and deer densities as a general feature of wolf–deer systems (Wydeven et al. 1995; Fuller et al. 2003).

Territories of founder CFR wolf packs decreased in size between 1995–1999 and 2000–2004, but not significantly so. Yearling wolves occasionally established territories that usurped edges of their natal pack territories, accounting for some of the observed reductions in sizes of territories of founder packs over time. Similar observations were made by Fritts and Mech (1981) and Hayes and Harestad (2000), but in those studies the decreases in territory sizes over time was significant.

High reproductive rates probably contributed to the population increase observed in the CFR. Fecundity among breeding females in the CFR, as measured by uterine placental scars, was high relative to those reported in Fuller et al.'s (2003) review, but this may be an artifact of the small sample size in the CFR data set. Similarly, we detected pups in most packs surveyed during summer howl routes. A high percentage of CFR packs reproduced annually, and surviving offspring likely colonized new CFR territories. Similarly, a significant number of dispersing radiocollared wolves either established new territories in the CFR or integrated into existing CFR packs. Thus, internal dynamics of the CFR population likely facilitated its rapid growth.

Mean yearly pack size was highly variable over the 10-year study but seemed related to periodic expansion of the CFR population. Years with larger mean pack sizes were associated with years when fewer new territories were detected. Mean pack size was also affected by pack location relative to RDs.

Changes in patterns of human activity, densities of rural residences, variations in human tolerance of wolves, and wolves'-demonstrated adaptability to humans alter the effect that RDs have on wolf habitat (Thiel et al. 1998; Kohn et al. this volume). Nonetheless, RDs seem to define wolf habitat in the Great Lakes region. Human-caused mortality accounted for 17–31% of wolf deaths in Minnesota (Fuller et al. 2003) where RDs are lowest. In northern Wisconsin, with intermediate RDs, 39–72% of wolf deaths were caused by humans from 1979 to1992 (Mladenoff et al. 1995, 1999, 2006; Wydeven et al. 1995). Wydeven et al. (2001) reported that 60% of human-caused wolf mortality occurred at RDs >0.63 km/km^2, and "most shootings and vehicle collisions occurred at RDs of 0.84–1.14 km/km^2." Our data on the CFR wolf population support the notion that RDs affect survival of wolves and shape wolf distribution (Mladenoff et al. 1995, 1999, 2006; Kohn et al. this volume).

As expected, human-caused wolf mortality predominated in the CFR. Packs within core habitat areas (mean RD = 0.76 km road/km^2) held 47% of the CFR population (172/365 wolves) over the 10-year census period, but sustained only 17% (3/18 wolves) of known human-caused mortality (shot or vehicle killed). Eighty-three percent of the human-caused mortality occurred in marginal habitat areas (mean RD = 0.94 km road/km^2). This corroborates Wydeven et al. (2001), who observed that 75% of wolf mortality in northern Wisconsin was human-caused in areas with RDs between 0.84 and 1.14 km/km^2. During our study, larger mean pack sizes tended to be in core habitat areas where RDs were lower (4.2 wolves/pack; 47 pack-years; 195 wolves) relative to marginal habitats where RDs were higher (3.1 wolves/pack; 68 pack-years; 211.5 wolves), though this difference was not significant ($P = 0.20$). Differences in human-caused mortality in the core (3/18 wolves) relative to marginal (15/18 wolves) habitats were likely the cause for differences in observed pack sizes. Higher human-caused mortality may suppress mean pack size in areas with higher RDs through higher turnover of both adult breeders and their offspring.

Mladenoff et al. (1995, 1999) determined that RDs were the best predictor of habitats capable of sustaining viable wolf populations, with a >0.50% probability of wolf occupancy associated with areas supporting RDs <0.45 km/km^2. Mech (2006), however, argued that RD thresholds were a poor predictor of wolf habitat suitability. RDs within the ranges of radioed CFR wolf packs ranged from 0.55 to 1.16 km/km^2 and, as a consequence, very little of the CFR has RD values below the Mladenoff et al. (1995, 1999) threshold. However, the CFR wolf population first occupied areas within CFR with lower RD (<0.80 km/km^2), as was also predicted by Mladenoff et al. (1995, 1999). Our data on patterns of wolf colonization and different mortality rates in regions with varying RDs support Mladenoff et al.'s (1995, 1999, 2006) general predictions that RDs do affect patterns of wolf colonization and wolf population demographics.While the Mladenoff et al. (1995, 1999)

RD threshold may be conservative in areas with established wolf populations and needs reevaluation, we feel it remains a very powerful predictor of geographic areas likely to be colonized by wolves.

Since 2000, CFR wolves have increasingly inhabited areas near humans. The edge of one pack's territory (Seneca pack) abuts the city of Wisconsin Rapids with a population of about 20,000 people. Other packs regularly establish rendezvous sites in cranberry beds within daily view of agricultural workers, and one pack established a territory on the Fort McCoy Military Reservation. CFR wolves have developed a tolerance toward humans that may necessitate a reanalysis of Mladenoff et al.'s (1995, 1999) RD thresholds as human-tolerant wolves continue to disperse and perhaps successfully colonize landscapes with even greater human activity (Thiel et al. 1998).

Survival of pups in the CFR was estimated from a single study (Heilhecker personal communication), and is low compared to other studies (Fuller et al. 2003). We feel our observed annual survival rate of 0.20 for pups is probably biased because of small sample size ($n = 16$), small numbers of packs, short duration of the study (2 years), and a high premature failure rate among ear transmitters in the second year of the project (Heilhecker personal communication). Our estimated annual suvival rate of 0.72 for adults was well above the threshold rate of 0.65 associated with stable populations (Fuller et al. 2003). These survival values were comparable to rates observed in northern Wisconsin during the late-1980s and early-1990s (Wydeven et al. 1995).

CFR pups less than 6-month old died from disease and parasitism, whereas more than 50% of mortalities in adult-sized wolves were caused by humans. This is not surprising since pups are less mobile and, therefore, less likely to encounter mortality risks associated with humans. Older wolves, by contrast, are more likely to encounter humans, given the relatively small size of the CFR, its proximity to relatively dense human population centers (including three cities with >40,000 residents within a 1-h drive of CFR), and the high RDs that provide access to humans.

The low depredation rates observed in CFR may be explained in part by an initial unawareness of wolves by residents, unfamiliarity in reporting procedures, and a paucity of livestock throughout most of the areas inhabited by wolves. Mech et al. (1988) reported an inverse relationship between rates of depredation and severity of the previous winter in northern Minnesota. They suggested that depredation rates were in part explained by the availability of vulnerable fawns, with mild winters leading to greater numbers of fawns and decreased depredations. Perhaps, high deer densities in CFR effectively provide wolves with a readily available food source and diminishes depredation rates.

Although the CFR is somewhat isolated geographically, two radioed wolves from farther north – one from Lincoln County, Wisconsin, and the other from Gogebic County, Michigan – were recovered dead within 20 km of CFR during this study. These dispersers demonstrated that wolves from the Lake Superior region can and, likely, do reach CFR regularly. Our data on 11 dispersers from CFR similarly documented 3 dispersers that left the CFR in northerly routes, one that reached

Michigan's Upper Peninsula, and one that moved southeasterly, reaching east-central Indiana. During our study, the CFR appeared connected to the more substantive Lake Superior basin wolf population by dispersal, and was a source for wolves moving or settling further to the south. The agricultural belt surrounding CFR, though consisting of relatively open, nonforested terrain, does not appear to be a barrier to wolf movement in either direction.

7.5 Conclusion

The CFR wolf population exhibited robust growth during our study. Once established, wolves rapidly colonized available core and marginal habitats. These wolves exhibited high reproductive and adequate survival rates. Dispersers have colonized local patchy habitats and replaced breeders within CFR, and wolves from CFR provided a source of dispersers that may reach distant suitable habitats.

We recognize that changes in human occupancy and use of CFR is inevitable and unpredictable. To ensure continued survival of wolves in the CFR we recommend annual winter-track surveys to estimate year-to-year population trends. We also recommend that more intensive radiotelemetry monitoring of CFR wolves be conducted over 2-year periods, every 5 years, to assess demographic trends, and to assess changes in territorial-spacing mechanisms and mortality rates otherwise not available from chance carcass recoveries.

Acknowledgments We acknowledge the work of numerous summer howl and winter track survey volunteers, various personnel of the US Fish and Wildlife Service at Necedah National Wildlife Refuge, US Department of the Army personnel, officials at Wood County and Jackson County Forestry, numerous Bureau of Wildlife Management staff within the Wisconsin Department of Natural Resources, and Matthew Schuler who performed the statistical calculations.

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