National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Vital Signs Monitoring of Wolf (*Canis lupus*) Distribution and Abundance in Denali National Park and Preserve, Central Alaska Network

Biological Year 2012 Report

Natural Resource Data Series NPS/CAKN/NRDS—2014/738

ON THE COVER
A yearling wolf from the Grant Creek Pack walks near the Denali Park Road.
NPS photograph by Tom Meier

Vital Signs Monitoring of Wolf (*Canis lupus*) Distribution and Abundance in Denali National Park and Preserve, Central Alaska Network

Biological Year 2012 Report

Natural Resource Data Series NPS/CAKN/NRDS—2014/738

Bridget Borg and John Burch
National Park Service
Denali National Park and Preserve
P.O. Box 9
Denali Park, Alaska 99755

Month 2014

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the Center for Resources, Science, and Learning, Denali National Park and Preserve website (http://www.nps.gov/dena), and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov**.**

Please cite this publication as:

Borg, B., and J. Burch. 2014. Vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Denali National Park and Preserve, Central Alaska Network: Biological year 2012 report. Natural Resource Data Series NPS/CAKN/NRDS—2014/738. National Park Service, Fort Collins, Colorado.

NPS 184/127394, December 2014

Contents

Contents (continued)

Appendix A. Figures

Page

Appendix A. Tables

Page

Executive Summary

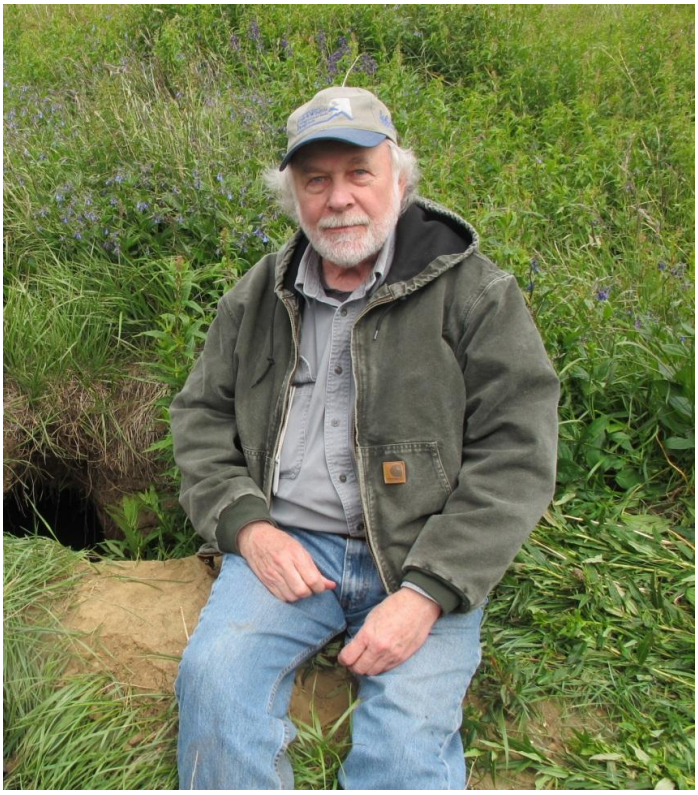
Wolves have been monitored with the use of radio collars in Denali National Park and Preserve (DENA) since 1986. This work was conducted by the National Park Service (NPS) from 1986 to 1994, by the U. S. Geological Survey (USGS) from 1995 to 2002, and again by NPS from 2003 to present. A total of 175 wolves have been captured since NPS resumed wolf monitoring efforts in 2003. Between February 2012 and March 2013, 24 wolves were captured and radio collared in or near DENA.

Each year, 9 to 20 wolf packs (average=13 packs) are monitored in or adjacent to DENA. Of 105 collared wolves that died between 2003 and 2013, 37 (35%) were killed by humans and 68 by natural causes, suggesting an increase in human-caused mortality in recent years. The data suggest an increase in human-caused mortality in the DENA wolf population as compared to the period 1986-2002, when only 17% of mortalities of radio-collared wolves were human caused. The estimate of wolf density in April 2013 was 3.2 wolves per 1000 square kilometers, lower than the density a year earlier, and below the 25-year spring average of 5.5 wolves per 1000 square kilometers.

The elimination of the Stampede and Nenana Canyon Closed Areas, which formerly protected wolves in certain areas adjacent to DENA, along with the presence of intensive management and predator control programs adjacent to DENA, has prompted concerns about impacts to the natural and health status of DENA's wolf populations and impacts to visitor opportunities for viewing wolves. A study, conducted by Bridget Borg of the University of Alaska-Fairbanks and NPS, used GPS collars specifically programed to study the movements of wolves living adjacent to the park road. The data gathered through the research study will be used to analyze wolf movements and wolf mortality patterns to help address these questions about impacts.

Acknowledgments

This report is dedicated to Tom Meier, long time wolf biologist and Denali's supervisory wildlife biologist who passed away in August 2012.



Tom Meier at the Murie Den site, July 2012.
Photo Credit: Christina Eisenberg

John Burch and Bridget Borg (NPS) captured wolves and provided suggestions for data analysis. Helicopter pilots Rick Swisher (Quicksilver Air) and Troy Cambier (Chena River Aviation), and fixed-wing pilots Dennis Miller (Caribou Air), Sandy Hamilton (Arctic Air Alaska), and Colin Milone (NPS) piloted aircraft on wolf capture and radio-tracking flights. Melanie Cook (NPS), Dr. Sandy Talbot (USGS), and Dr. Robert Wayne (University of California, Los Angeles) performed genetic analysis of wolf specimens. Regan Sarwas of the NPS Alaska Regional Office GIS team developed new tools for processing and analyzing wolf location data. Telonics, Inc. (Mesa, AZ) developed radio collar designs to address unique problems of monitoring wolves in Alaska. Dr. Kimberlee Beckman of the Alaska Department of Fish and Game performed wolf necropsies and arranged for immunological testing of wolf blood specimens. The Washington State Animal Disease Diagnostic Laboratory performed immunological testing of wolf specimens. Jane Bryant, Grant Hilderbrand, and Bridget Borg served as observers during wolf capture operations. Philip Hooge, John Burch, Grant Hilderbrand, Pat Owen and Maggie MacCluskie (NPS) reviewed this manuscript and provided additions and corrections.

Introduction

This report summarizes efforts to monitor wolves (*Canis lupus*) in Denali National Park and Preserve (DENA), Alaska, through spring 2013. Wolves occur in all three parks of the Central Alaska Monitoring Network (CAKN): DENA, Yukon-Charley Rivers National Preserve, and Wrangell-St. Elias National Park and Preserve. Wolves are one of six keystone large mammal species in interior Alaska, along with grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), moose (*Alces alces*), caribou (*Rangifer tarandus*), and Dall's sheep (*Ovis dalli*). Wolves are of great importance to people from both consumptive and non-consumptive viewpoints, and to the ecosystem as a whole. As a top predator, wolves may play a key role in influencing ungulate populations, and as a result may influence vegetation patterns and promote species diversity (Miller et al. 2001, Ripple and Beschta 2003). The effects of wolves on ungulate populations (Mech and Peterson 2003) may be important determinants of ungulate availability for subsistence harvest on National Park Service (NPS) park and preserve lands in Alaska, and harvest by the general public on NPS preserve lands (NPS 2003). Data obtained from wolf monitoring are used to assist with wolf den site protection and other aspects of the Denali Wolf-Human Conflict Management Plan (NPS 2007).

Wolves are a species specifically identified in the enabling legislation and management objectives of all three CAKN parks (U. S. Congress 1980). Wolves are of great importance to park visitors because of the unique opportunities to view wolves in Alaskan parks. While the primary objective of monitoring is to track the distribution and abundance of wolves, a variety of additional data is obtained in the monitoring process. This information is likely to have great value for wildlife management and research. The body of data on wolf populations in Alaska parks is of great value in developing scientific models of predator/prey systems. In heavily visited portions of the parks, managers want to know the locations of active wolf dens and rendezvous sites (pup rearing areas) so that they can be protected from disturbance. When intensive wolf harvest or wolf control take place near parks, it is vital to know the patterns of travel of park packs, in order to determine whether they are being significantly impacted by activities outside of the parks. Data on the genetic, morphological, and immunological characteristics of wolves, obtained in the course of wolf capture, will be important in evaluating long-term changes in wolf populations in Alaska.

Parkwide monitoring of wolves in DENA was initiated by Resource Management Ranger John Dalle-Molle in 1986, with principal investigators L. David Mech and Layne Adams. Field work between 1986 and 1994 was performed by John Burch and Tom Meier. From 1995 through 2002, Layne Adams, now with U.S. Geological Survey (USGS), conducted wolf monitoring efforts. Since 2003, John Burch and Tom Meier have again conducted the field work (Meier 2009). Following Tom Meier's death in August of 2012, Bridget Borg, John Burch and Grant Hilderbrand have jointly managed the wolf project.

Measurable Objectives

- Locate non-radio-collared wolf packs using Park and Preserve lands by aerial snow tracking.
- Capture and radio-collar 1-3 individuals in each wolf pack identified in the study area.
- Determine the demography (numbers, colors, age structure) of monitored wolf packs.
- Obtain morphological measurements from captured wolves.
- Obtain genotypic data (mitochondrial and microsatellite DNA) from captured wolves.
- Obtain immunological (disease exposure) data from captured wolves.
- Determine pack size for each collared pack in fall (early winter) and spring (late winter).
- Define the mosaic of wolf home ranges (population area) for estimating wolf densities.
- Perform annual capture efforts to maintain coverage of radio collars in the population.
- Detect pack extinction and pack formation events in the population.
- Detect changes in wolf density over time.
- Detect changes in wolf pack sizes over time.
- Detect changes in wolf home ranges over time.
- Detect changes in the morphological, immunological, and genetic makeup of the wolf population over time.
- Investigate the effects of wildlife management activities on the natural and healthy character of wolves in DENA.
- Investigate the biological and social characteristics of wolf viewing by visitors in DENA, and factors that may affect wolf viewing opportunities.

Methods and Materials

This report spans the biological year 2012, defined for the DENA wolf population as May 1, 2012 to April 30, 2013. Note that Alaska Department of Fish and Game (ADF&G) regulatory years and harvest periods differ from the biological year defined for this report (regulatory year as defined by ADF&G is July 1, 2012 to June 30, 2013, with wolf hunting in all of unit 20 open from August 10 to May 31 with a bag limit of five wolves and the trapping period for Game Management Units 20A and 20C set from November 1 to April 30, with no bag limit).

Collaring

DENA has been collaring members of the wolf population since 1986 in order to track movements, estimate territory locations and sizes and estimate the population size and density. Current methods of wolf monitoring used in DENA followed the Wolf Monitoring Protocol for Denali National Park and Preserve, Yukon-Charley Rivers National Preserve and Wrangell-St. Elias National Park and Preserve, Alaska (Meier et al. 2009). In brief, this method involved capture and radio-collaring of one or two members of each wolf pack in the study area and locating and counting wolves during aerial tracking flights periodically through the year. Morphological data, including sex, weight, age and color, and blood and tissue samples for genetics and disease analysis, were gathered from captured wolves.

Both conventional Very High Frequency (VHF) and GPS collars (both manufactured by Telonics) were deployed on wolves. The majority of GPS collars obtained one location each day and stored the location coordinates within the collar. The data were uploaded weekly through the ARGOS satellite system, and also remained stored within the collar so that all data can be recovered if the collar is retrieved. In March 2011, as part of a two-year study focusing on the Denali Park Road, six specially programed GPS collars were placed on wolves that live near the park road; two each from the East Fork, Grant Creek, and McKinley Slough Pack. Designed to provide more detailed data on the movements of these packs, the collars determine each wolf's location every three hours. The road study GPS collars were equipped with breakaway devices and the collars automatically dropped from the wolves in September 2012.

Population Monitoring

Between May 1, 2012 and April 30, 2013, collared wolves were located approximately twice per month by aircraft, with more frequent aerial tracking flights occurring during May (to locate den sites), September (to obtain pup counts), during fall and spring capture operations, and from November through December and February through April to obtain early and late winter census data. Pack counts obtained from aerial tracking flights were used to obtain mean pack size and population estimates.

Pack Territory and Population Area Estimation

An exception to the standard data analysis was the determination of wolf pack territories. Wolf pack territories were estimated using minimum convex polygons (MCPs) of the final wolf locations. MCPs are essentially a "connect the dots" method for estimating home range sizes, often removing a certain percentage of the "most extreme" points (those farthest away from the center of the locations). For the wolf territory maps from 2003 to 2012 (Figures A.1-A.9, Appendix A) wolf pack territories were not rigorously calculated using the 95% of locations that would produce the smallest home range, instead the authors manually removed selected wolf locations that were thought to represent extraterritorial forays or pre-dispersal movements by the collared animals. In implementing this method, subjective decisions were by made NPS wildlife biologists to exclude forays by wolf packs outside of their usual range, so that the population area was not inflated by the inclusion of areas that were actually occupied by other, uncollared wolf packs. Dispersing or lone wolves were not included in population size or density estimates. An appropriate protocol (e.g., harmonic mean removal of dispersed points) is being considered to automate the selection of the most extreme points.

The present method of determining the population area involved the use of minimum convex polygons to estimate individual wolf pack territories, and combining a number of territories into a larger, non-convex polygon representing the population (Burch et al. 2005). Population density estimates were derived as the total number of wolves/population area as calculated as using MCPs.

Mortality

Wolf mortalities were noted during aerial tracking and observation and through weekly GPS data checks. An effort was made to recover all collars and determine cause of death of the collared individual. Mortality data were collected on the Denali Wolf Mortality Record form. Occasionally

carcasses were brought to the ADF&G for necropsy to determine cause of death. Otherwise, cause of death was determined in the field through a field necropsy or external examination. When the carcass was consumed or decomposed to the point where cause of death was inconclusive, the cause of death was often recorded as “unknown natural” unless there was significant reason to conclude that there was an anthropogenic cause of mortality.

The number of wolves trapped or shot in a regulatory year were obtained through the ADF&G records. The trapping period for wolves in Game Management Units 20A and 20C spans November 1 to April 30, with no bag limit, and the hunting season runs from August 10 until May 31 outside the park. Hunters and trappers are required by law to seal furbearers (including wolves) by an authorized ADF&G representative within 30 days after the trapping season has closed in the unit where the fur was taken. Thus sealing records were not provided until after the closure of season (April 30).

Reproduction

Den and rendezvous locations, activity at den locations, number and color of pups were recorded during aerial tracking flights. Occasionally den site and rendezvous locations were ascertained from GPS locations of breeding individuals. Fall aerial tracking and survey flights focused on obtaining repeated adult and pup counts and were used to estimate recruitment rates of pups from spring to fall.

Results

Collaring

Fourteen wolves from eight packs were captured and radio-collared in biological year 2011-2012 and ten wolves from seven packs were captured in winter 2012-2013 (Table A.4, Appendix A). One pack, the John Hansen pack, was found and collared for the first time in March 2013. A total of 33 different radio-collared wolves from 11 packs were monitored for some or all of this period, resulting in 445 aerial tracking locations of collared wolves, and between 2 to 69 locations per pack (Table A.6, Appendix A). In addition, 5,549 locations were obtained from 21 wolves that wore GPS/ARGOS collars for some or all of this period.

Morphologic data are presented in Table A.4 (Appendix A). Genetics results are being analyzed by biologists at the USGS Alaska Science Center and University of California Los Angeles (UCLA). Wolves living in or near DENA have occasionally been found to be infested with the dog louse *Trichodectes canis* and also with another coat abnormality of unknown origin (Beckmen et al. 2009, Wolstad et al. 2009). Immunological surveys of wolves in interior Alaska have revealed exposure to a number of diseases but have not detected evidence of serious population effects of disease (Zarnke and Ballard 1987, Mech et al. 1998, Zarnke et al. 2001). One disease that has the potential to seriously affect wolf pup survival is Canine Parvovirus (CPV). Immunological studies of DENA wolves have revealed a rate of exposure to CPV as high as 50% in some years, among wolves that were captured and blood sampled (R. Zarnke, retired wildlife ecologist/veterinarian, pers. comm.).

Population Monitoring

Radiotracking flights in spring 2013 observed 49 wolves, 22 of them radio-collared. These wolves were found in eleven packs covering an estimated area of 15,473 square kilometers, mostly within the boundaries of DENA north of the Alaska Range (Figure A.9 and Table A.3, Appendix A). Two wolves were seen on the Foraker River and not collared, but included in the population estimate-unofficially named as the “Squeeze” pack (Table A.3, Appendix A). These counts produced a density estimate of 3.17 wolves per 1000 square kilometers, a decrease from the spring 2012 count of 70 wolves in 10 packs and density of 3.82 wolves per 1000 square kilometers.

The number of wolves in late winter in DENA has varied from about 60 in 1986 and 2010 to over 130 during 1990-92 (with densities ranging from 3.1 to 7.8 animals per 1000 square kilometers). During the late 1980s a series of higher than average winter snowfalls increased the vulnerability of the animals that wolves prey on, allowing wolf numbers to increase (Figure A.8, Appendix A). By the mid-1990s, prey numbers declined and winter snowfalls returned to more average levels. Wolf density since then has varied from about 3.5 to 6.7 wolves per 1000 square kilometers (60 to 120 wolves parkwide) in late winter, and 5.2 to 8.3 wolves per 1000 square kilometers (89 to 143 wolves parkwide) in early winter. Since fall 2008, wolf densities have been in the low range of recorded densities with an apparent decreasing trend. From 2008 to 2012, early winter densities ranged from 3.1 to 5.2 wolves per square kilometers (54 to 90 wolves parkwide) and the last three years’ wolf density (from 2010 to 2013) have been the lowest recorded since 1986. From 2009 to 2012, spring population estimates ranged from 3.5 to 3.9 wolves per square kilometers (60 to 68 wolves

parkwide). Wolf densities for the past five years have been the lowest in DENA since 1987 (Table A.1 and A.2, Figures A.8 and A.9, Appendix A).

Mean pack size in late winter has varied from 4.2 to 10.6 from 1986 to 2013 (Table A.2, Figure A.11, Appendix A). The late winter mean pack size in 2013 of 4.5 is the fifth lowest mean pack size and below the 25-year mean pack size of 5.5 wolves per pack.

Pack Territory and Population Area Estimation

Territory ranges for eleven wolf packs were calculated using 100% MCPs using a total of 5235 locations from GPS and aerial tracking observations. The total population area was estimated at 15,473 km^2 (Figure A.9, Appendix A).

Mortality

Ten mortalities of collared wolves occurred in biological year 2012. Three wolves were harvested, one wolf died from injuries from other wolves, four died of unknown natural causes, two wolves died of starvation/dehydration secondary to other injuries/illnesses (1108GM died of starvation due to a rare oral melanoma in its upper jaw, and 1206BM died of uremic poisoning and dehydration secondary to paralysis from unknown causes). Table A.4 summarizes the fates of wolves captured and radio-collared between March 2003 and March 2013. Of 107 radio-collared wolves that were captured during this period and subsequently died, at least 35% were killed by humans. Two of those were trapped within Park/Preserve boundaries.

Reproduction

Of the ten packs monitored in 2012, seven packs denned at known locations, and it is unknown if two packs denned. Only one pack was confirmed to have attempted to den without success (see Grant Creek pack narrative). In four cases, we confirmed the number of pups that survived until fall (Table A.5, Appendix A). The average recruitment rate was 3.4 pups per pack in 2012.

Discussion

Population Monitoring

Current wolf population and density estimates along with mean pack size indicate that the wolf population is at a current low. No obvious explanation for the current low density estimate is apparent, and there are likely a number of ecological and methodological factors resulting in the recent low density estimates.

First, it is important to note that wolves exist at a wide range of densities throughout their range and it is not uncommon for studies in arctic regions to record healthy wolf populations with spring densities less than 5/1,000 km^2 (reviewed in Fuller et al. 2003). For example, the 20-year average spring density for wolves in Yukon-Charley Rivers National Preserve is 2.85/1,000 km^2 (Burch 2013). Density (population size divided by population or study area) is a useful metric to evaluate how wolf populations vary compare one population to another because density can vary widely depending on prey density and vulnerability between study areas (Fuller 1989, Fuller et al. 2003). When comparing across populations, mean pack size may be equal, but density estimates could range five- to ten-fold (Mech 1986, Fuller 1989, Fuller et al. 2003). However, mean pack size maybe be a better metric for annual comparisons of wolf population change within the same population, because it does not rely on an accurate measure of area (Burch 2011). Thus, assuming a relatively consistent distribution of packs across a region, the mean pack size may provide a way to track population trends more accurately than density estimates. Mean pack size at DENA, which has generally tracked population trends does not show the same trending decline since fall 2008; however, there has been a decrease in mean pack size since fall 2011 and mean pack size is currently at the fifth lowest observed since 1986 (Figures A.10 and A.11, Appendix A).

Additionally, although the challenges of locating all packs and obtaining accurate counts of pack size lend a level of uncertainty to the population estimate, the consistent methodology, ongoing aerial tracking, and low personnel turnover support the validity of the population estimation and resulting population trend. The aerial tracking methods used in the DENA wolf program attempt to count every wolf in every pack to give a complete population census. The presence of radio-collars on wolves within most packs facilitates locating packs. However, natural and anthropogenic mortality, movement of wolves in and out of packs, formation of new packs, and the splitting of an existing pack into two or more packs make it difficult to maintain contact with all of the packs at all times. GPS data may help identify and target "gaps" where uncollared packs may reside. These uncertainties are compounded with the difficulties of weather, especially in the early winter months when days are short and snow cover may be patchy making it difficult to see tracks and wolves. However, the challenges of wolf population census techniques have been relatively unchanged over the duration of the study.

Pack Territory and Population Area Estimation

The present method of determining the population area involves the use of MCPs to estimate individual wolf pack territories, and combining a number of territories into a larger, non-convex polygon representing the population (Burch et al. 2005). Population density estimates are derived as

the total number of wolves/population area as calculated using MCPs. With the advent of GPS collars and advances in battery life and technology, more locations are being collected via GPS collars. Increases in the number of locations used during MCP estimation may produce larger home range estimates and larger population area estimates, which cause the density estimate to decrease (Burch et al. 2005). CAKN and DENA personnel are developing methods that might provide a more objective estimate of pack territories and population area and deal with variations in the number of locations used to calculate wolf territory (NPS, J. Schmidt, Biometrician, Central Alaska Inventory and Monitoring Network, pers. comm.).

In particular, utilization distributions (UDs) are often presented as a more rigorous alternative for estimating individual home range, group territories or population areas compared to other commonly used methods such as MCP (White and Garrott 1990). UDs are often used in ecological studies to create a three-dimensional surface that describes the density (or frequency) of an animal's use of space within a study region. The principle for UD estimation using kernel density estimators is that a bivariate kernel (essentially a bump) is placed over each relocation of an animal, and a probability density function is derived as the sum of the kernels at any point (or within a grid cell). UDs are a smoothed map that represents the probability of an animal relocation in an area, based on known locations. Home range or territory estimation using UD can be estimated at a different probability levels, for example, the 95% home range would be the area under which the probability to relocate an animal would be 0.95.

Mortality

The data suggest an increase in human-caused mortality in the DENA wolf population from the period 1986-2002, when only 17% of mortalities of radio-collared wolves were human-caused to the period 2003-2013 where 35% of mortalities of wolves were caused by humans (Figure A.12, Appendix A).

Intraspecific strife (the killing of wolves by members of neighboring wolf packs) probably remains the leading cause of wolf mortality in DENA (Mech et al. 1998), but many carcasses are consumed or decomposed before they can be investigated. Though only 22% of radio-collared wolf mortality between 2003 and 2013 was documented as wolf-caused, 35% of the mortalities were classified as unknown natural cause; and, it is likely that many of those mortalities were also wolf-caused.

Beginning in 2000, the State of Alaska established the Stampede Closed Area to protect wolves west of the Savage River (Figure A.11, Appendix A) from harvest, in order to preserve wolf viewing opportunities in DENA. In 2003, the Nenana Canyon Closed Area, a narrow strip of land east of the George Parks Highway, was created for the same purpose. During the 2010 Interior Region meeting, the Alaska Board of Game voted to eliminate both of these closed areas.

In regulatory year 2011, at least two wolves were taken in within the former closed areas. One was Grant Creek 1103GM (see pack narratives). It is unknown how many wolves have been harvested in areas adjacent to park boundaries during 2012-2013. One collared wolf was harvested (shot) outside of park boundaries near Cantwell in spring 2013. The wolf was a recently collared female from the Grant Creek pack (1301GM).

Reproduction

Previous years' reports do not include denning information, or estimated pup production, survival and recruitment and these data have not been previously compiled. Analysis of current and past reproduction data is pending.

2012 Pack Narratives

NOTE: Pack narratives span the biological year for wolves (May 1, 2012 to April 30, 2013). Wolf identification numbers are created as follows: first two digits refer to the year they were first collared, second two digits are assigned sequentially to wolves collared for the first time that year, the first letter indicates the color of the wolf (G-gray, B-black) and the second letter indicates the sex (F-female, M-male). Thus 0811GM is a gray male wolf that was the 11th wolf collared in 2008.

Eastern Packs

Nenana River (7 wolves)

In spring 2012, the Nenana River pack was comprised of four individuals: 1105GM, the three-year old breeding male and 0905GF, the five-year old breeding female and two yearlings from the prior year's breeding. The pack raised four pups at a den site above Hines Creek, and there were a total of eight wolves in the pack in fall 2012. During the summer, the pack traveled between the Savage and Nenana River and south of Mount Healy. During fall and winter 2012-13 the pack primarily traveled south and east of their summer territory and were seldom within the park boundary. In spring 2013, the pack numbered seven individuals, indicating that at least one uncollared wolf dispersed or died over the winter.

Grant Creek (2 wolves)

The Grant Creek pack experienced a dramatic decline in numbers in 2012, from 15 members in spring 2012 to three members in spring 2013. This decline potentially resulted from the loss of two breeding females in spring 2012. In March 2012, the Grant Creek pack numbered 15 members with three collared individuals, six-year old breeding male 0811M, seven-year old breeding female 0719GF, and three-year old 1103F. Wolf 0719F was the breeding female in the Grant Creek pack and raised pups in 2008, 2009, and 2010. However, in 2011, it is suspected that 1103F was the only female in the Grant Creek pack that whelped pups (4 pups). In early April 2012, 1103F was legally trapped near a horse carcass less than a mile outside the park boundary on the west side of the Savage River. Wolf 0719F died near the East Fork Aspen wolf den in mid-May of 2012 of unknown natural causes. The carcasses of 1103F and 0719F were scavenged before the carcasses were recovered, making it impossible to tell whether they were carrying pups at the time of mortality.

GPS data indicated that Grant Creek wolves were still frequenting the East Fork Aspen den area after the death of wolves 0719F and 1103F. On June 13 and 14, 2012 NPS biologists observed the Grant Creek wolves at or near the den site for over 12 hours. That was the last time ground or aerial observers noticed the wolves using the den site. At that time, there were six wolves in the pack including the breeding male, wolf 0811M.

On August 8, 2012, wolf 0811M was observed with three other wolves at mile 60 along the park road. A seasonal wildlife technician noticed one of the wolves had visible nipples, an indication that this female may have had pups or lactated earlier that season. However, during subsequent aerial and ground observations, no pups were seen. It is possible that there was a third breeding female within the pack (observed August 8) but that the pups failed to reach recruitment age. All sexually mature females exhibit a long post-ovulation phase, often called pseudopregnancy, during which there is no

hormonal difference between pregnant and pseudopregnant females (Seal et al. 1979, Asa et al. 1986, Kreeger et al. 1991). Thus, all females that ovulate are hormonally primed to show maternal behavior and some may even lactate (Asa and Valdespino 1998) following pseudopregnancy.

From July to November 2012 five wolves were observed consistently in the pack, which ranged widely over the territory formerly occupied by the larger pack of 15 and over regions south of the Alaska Range.

Other members of the Grant Creek pack may have dispersed, died, or the pack may have split, resulting in two smaller packs that either share the same territory or use exclusive territories. However, extensive aerial tracking in fall 2012 and spring 2013 did not located an uncollared pack within the region formerly used by the Grant Creek pack.

By February 2013, there were only three members left in the Grant Creek pack, the collared breeding male, wolf 0811M and two other gray colored wolves. One of 0811M's companions was captured and collared in March 2013. This newly collared female, 1301F was estimated to be two years old at the time of capture. Following capture in March 2013 to mid-April 2013, 1301GF was been traveling independently of 0811GM. In mid-April 2013, 1301GF was shot near Cantwell with an uncollared gray male companion. Since April 0811GM has been seen repeatedly with one gray companion. In spring 2013 0811GM and his companion were confirmed to be denning at the East Fork Aspen den.

East Fork (9 wolves)

At nine members in spring 2013, the East Fork pack is currently the largest pack in the eastern region of the park and occupies a territory in the north eastern corner of the park, traveling frequently in and out of the park boundaries. In spring 2012, there were eight members in the East Fork pack, five gray and three black wolves. There were a total of four wolves collared in the East Fork pack from spring 2012 to September 2012, when two collars automatically released and were recovered. These short term collars were placed on wolves in three eastern region packs (East Fork, Grant Creek and McKinley Slough) as part of a wolf viewing study and were programmed to release automatically from the wolves in September 2012.

Interestingly because we monitored additional wolves in the pack this year, we discovered that that the East Fork pack used two den sites located 12 miles apart in summer 2012. If we had only monitored the dominant breeding female, 0618GF, a nine-year old wolf, it is unlikely that we would have located the second den site. 1203BF, a two-year old wolf collared for the wolf viewing project denned along the Sanctuary River in 2012 and produced at least 4 pups. The other two collared wolves, 1201GM, a three-year old male collared with a short term collar, and 1202BF, a four-year old female, alternated between the two den sites throughout the summer. Even the breeding females, 0618GF and 1203BF visited their pack mates' den sites, as indicated by GPS and aerial tracking data. Prior to 2012, the East Fork pack used the same den site (or various dens near the same location) on the Teklanika River for 13 consecutive years.

By August four pups (one black, three gray) of unknown maternity and all adults were traveling near Sanctuary and appeared to have joined and used a rendezvous site across the river from the Sanctuary

den. In November 2012, the East Fork pack was up to 13 members (nine adults, and three pups). By the end of March 2013, the East Fork pack numbered eight wolves in (three black and five gray). It is unknown if the overwinter decrease was due to natural mortality or harvest. No collared wolves were known to be harvested as of the end of April 2013.

McKinley Slough (5 wolves)

The McKinley Slough pack experienced a dramatic decline from 2012 to 2013, dropping from 15 members in spring 2012 to only five members in fall 2012 and spring 2013. Similar to Grant Creek, this decline in pack size may be a result of the loss of a breeding female, six-year old 0702GF, who died of unknown natural causes three miles south east of Diamond in July 2012.

The McKinley Slough pack used a potential den site near Little Bear and Alder Creek in 2012, although the den location was never confirmed. There was only one pup seen with the adult pack members in the fall.

Wolf 1211GF, a four-year old female was the only collared member of McKinley Slough pack from July 2012 to March 2013. She was seen with five other wolves in spring 2013 and one of her companions 1306GM, was collared in March 2013. 1306GM was collared on Chitsia Mountain on March 4, 2013, weighing in at 116 lbs. 1306GM's general body condition was excellent, but he had no apparent testes and a short and deformed penis perhaps from a birth defect or injury. No other abnormalities were observed.

1107GM, a two-year old collared as part of the wolf viewing project dispersed from the pack beginning in June 2012. 1107GM departed the park near Bearpaw Mountain and traveled northwest, eventually reaching the Seward Peninsula, over 350 miles straight line distance in less than a month. The GPS collar on 1107GM was a short-term collar, and automatically released in September 2012.

There appears to be a unique relationship between the Iron Creek East pack and the McKinley Slough pack. Two collared members of McKinley Slough were observed, via GPS and aerial tracking, to spend a period of time alternating between the Iron Creek East pack and the McKinley Slough pack before eventually joining the Iron Creek East pack. 1106GF was captured in March 2011 as a two-year old McKinley Slough member. By July 16, 2011 GPS data indicated that she was traveling with Iron Creek 1108GM. However, by the end of November 2011, 1106GF was traveling with McKinley Slough again. In March 2012, 1106GF rejoined 1108GM and was officially renamed as the Iron East pack.

1205GF was collared in March 2012 as a four-year old member of the McKinley Slough pack. She traveled alternatively with McKinley Slough and Iron Creek East throughout the summer months in 2012 until she appeared to associate solely with the Iron Creek East pack and was renamed as an Iron Creek female in September 2012.

Western Packs

Bearpaw (6 wolves)

The Bearpaw pack numbered six individuals in spring 2012. Bearpaw denned near lower Flume Creek summer 2012 and produced five pups (four gray and one black). By fall, the Bearpaw pack

was the largest pack in the western region of the park, with a pack size of eight. Unfortunately, both dominant individuals in the pack died during the winter. The dominant female, 0415GF died of unknown natural causes near Flume Creek. The dominant male, 1206BM, a four-year old, died in early winter near Chitsia and Flume Creeks due to uremic poisoning and dehydration secondary to paralysis. The cause of paralysis was undetermined.

The remaining collared member, 1006BF, a two-year old female has been traveling with the remaining members of the pack (presumably all pups). In March 2013, one of the pups, 1307GF was collared in the Bearpaw pack, although GPS data from spring 2013 indicate that 1307GF may be dispersing northwest of the park.

Hot Slough (4 wolves)

In 2012, the Hot Slough pack occupied the northwest corner of the park west of Herron River to Munsanti Ridge and experienced a decline from nine members in spring 2012 to four members in spring 2013, due to splitting of the pack. During the spring, Hot Slough 1008BF, a two-year old, split from 0805GF and other Hot Slough pack members and denned near Telida. It is unknown if she had pups. It did not appear the 0805GF or other members of Hot Slough denned or raised pups in 2012. In March, a three-year old male 1304BM was collared in the Hot Slough pack and is suspected to be the breeding male of the pack.

Hot Slough West (? wolves)

During the spring, Hot Slough 1008BF, a two-year old, split from 0805GF and other Hot Slough pack members and denned near Telida. It is likely, given her tenure at the den site that 0805GF had at least one pup, but no pups were ever seen. In September, 0805GF was together with 1008BF nine miles northeast of Telida. It was the farthest west 0805GF had been seen previously. In subsequent observations, 0805GF has been east with four other pack members. 1008BF remains localized in a territory (?) out of the study area.

Iron Creek East (3 wolves)

In 2012, the Iron Creek pack split into two smaller packs, named the Iron Creek East and Iron Creek West packs. Iron Creek East pack primarily ranged from the south end of the Kantishna Hills to Turtle Hills and denned along Glen Creek in 2012, although pups were never seen at this den site. The fall pack size was three following the death of 1106GF and 1108GM. The pack size in spring 2013 remains at three wolves.

1108GM was collared in March 2011 as a member of the Iron Creek pack and died September 2012 of starvation due to a rare oral melanoma that impacted its ability to hunt and eat.

1106GF joined the Iron Creek East pack in spring 2012 after traveling with both the McKinley Slough and Iron Creek East packs alternately for much of 2011 (see McKinley Slough pack narrative). In August 2012, 1106GF died of unknown natural causes near the confluence of Boundary and Stony Creeks.

1207GF, five-year old female, originally collared in 2012 as a member of the Iron Creek pack and 1205GF, originally a member of the McKinley Slough pack (see McKinley Slough pack narrative) together with one other companion currently form the Iron Creek East pack.

Iron Creek West (2 wolves)

In 2012, the Iron Creek pack split into two smaller packs, named the Iron Creek East and Iron Creek West packs. The Iron Creek West pack ranged between the McKinley and Foraker rivers, just north of the Alaska Range and south of the Park Road. They used a den site just west of the Foraker River; however no pups were ever confirmed. The pack fell from seven wolves in fall 2012 to two wolves in spring 2013.

1001GF, originally collared as a pup in 2010 as member of Iron Creek pack, died from apparent injuries from other wolves in near McLeod Creek in February 2013. The remaining collared wolf in the pack, 1208GF, was originally collared in March 2012 and continues to travel in the Iron Creek West Territory with one companion.

John Hansen (5 wolves)

In March 2013, a new pack was located along the McKinley River near Kabena Hill. Collars were placed on the presumed dominant members of the pack, 1302GM, a two-year old gray male and 1303GF a four-year old gray female. Both wolves had a coat abnormality consisting of some guard hair loss, likely follicular dysplasia (Beckmann et al. 2009) but were otherwise in good condition. This pack may be an offshoot of the former Kantishna River pack, which once held a territory in this region prior to merging with the Somber pack in 2011. Alternatively, the pack may be a remnant or related to the former Starr Lake pack or the McKinley Slough pack. In 2013, the John Hansen pack used the same den site that the former Starr Lake pack used. Pending genetic analysis could help determine if collared members of this pack are related to any of the aforementioned packs.

Somber (5 wolves)

The Somber pack territory lies mainly between the western edge of the wilderness and park boundary along the Swift Fork. The current Somber River pack is the result of the Kantishna River and Somber packs merging in winter 2010-2011 when 0617BM, originally a member of the Kantishna River pack joined with Somber 0708GF. 0708GF died of unknown natural causes in August 2011 and 0617BM was last heard in September 2011 west of the Swift Fork. In 2012, the Somber pack denned near the Swift Fork and produced three pups. Two collared wolves, 1109BM, a four-year old male, collared in 2011 as a Somber pack member and 1210GF, a four-year old female died in spring 2013. The mortalities were first noted in May 20, 2013. Currently there is one remaining collared pack member, yearling 1305GM.

Boot Lake (Out of study area, not monitored)

The Boot Lake pack currently resides outside of the southwestern corner of the park and is not actively monitored. Current collared pack members 0904GM.

Wolf Program Review

Periodic review of any ongoing research programs is wise and the DENA wolf program has been the subject of reviews in the past. Park leaders requested a programmatic review at this time for a variety of reasons, not the least of which was the unexpected death of Tom Meier, Denali's leading wildlife biologist and wolf program manager in August 2012. In addition, in spring of 2013 DENA received a new superintendent, which coincided with a 25% turnover in staff, overall. Finally, given concerns due to wolf reduction efforts on adjacent lands, potentially diminished viewership opportunities, and the perpetual challenges of programmatic budgets and staffing, a review was warranted.

The NPS invited a group of professional biologists, researchers, educators, and managers to attend a one-day facilitated workshop at the Murie Science and Learning Center on January 23rd, 2013. The workshop included participants from DENA staff, NPS staff from other parks in the Alaska Region (Lake Clark and Yukon-Charley), the Alaska Regional Office, the NPS Inventory and Monitoring Networks, parks in other NPS Regions (Yellowstone), the ADF&G Division of Wildlife Conservation, the University of Alaska – Fairbanks, and the USGS.

The review focused on four key questions:

1. What are the key near term and long term management issues and decisions facing the park and what data needs help best meet these demands?
2. What is the educational opportunity/obligation of the Park/program?
3. How does the Denali wolf program provide benefit to and benefit from other wolf projects on Alaska NPS Units?
4. What is the role of the Denali program relative to broader statewide and global wolf biology and conservation?

Final results from the review are pending, but current plans are to maintain collaring efforts to assess reproduction and mortality and continue den site monitoring in 2013 (NPS 2013).

Plans for the Coming Year

In 2013-2014, we plan to maintain contact with approximately 10-12 wolf packs inside or partly inside DENA. Collars will be maintained on two members of each pack if possible. Monitoring efforts will continue, with wolves being located about twice per month. Extra monitoring flights will occur in spring and fall to document pack sizes and pup production.

In conjunction with CAKN biometricians, we plan to reevaluate our current home range and population area estimation techniques in 2013. In addition, we foresee the implementation of a new database structure for historic and current data in 2013-2014. Analysis and conclusions from the wolf sightability study are due in 2013 as well. Dr. Steve Arthur has been hired as DENA's supervisory wildlife biologist and will begin working with the wolf project in August 2013.

Literature Cited

Asa, C. S., U. S. Seal, E. D. Plotka, M. A. Letellier, and L. D. Mech. 1986. Effect of anosmia on reproduction in male and female wolves (*Canis lupus*). Behavioral and Neural Biology46:272-284.

Asa, C. S., and C. Valdespino. 1998. Canid reproductive biology: an integration of proximate mechanisms and ultimate causes. American Zoologist 38:251-259.

Beckmen, K. B., G. D. Bossart, and K. Burek. 2009. A novel dermatopathy in Alaskan gray wolves (*Canis lupus*). Poster presentation at the Northwest Sectional Meeting of the Wildlife Society, Fairbanks, AK.

Burch, J. W. 2011. Annual report on vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Yukon-Charley Rivers National Preserve, Central Alaska Network: 2011 report. Natural Resource Technical Report. NPS/CAKN/NRTR—2011/485. National Park Service, Fort Collins, CO. Published Report-2175579.

Burch, J. 2013. Annual report on vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Yukon-Charley Rivers National Preserve, Central Alaska Network: 2012 report. Natural Resource Technical Report. NPS/CAKN/NRTR—2012/736. National Park Service. Fort Collins, Colorado.

Burch, J. W., L. G. Adams, E. H. Follmann, and E. A. Rexstad. 2005. Evaluation of wolf density estimation from radiotelemetry data. Wildlife Society Bulletin 33(4):1225-1236

Fuller, T. K. 1989. Population dynamics of wolves in north-central Minnesota. Wildlife Monograph 105.

Fuller, T. K., L. D. Mech, and J. F. Cochrane. 2003. Wolf population dynamics. Pages 161-191 *in* L. D. Mech, and L. Boitani, editors. Wolves: Behavior, ecology, and conservation. University of Chicago Press. 448 pp.

Kreeger, T. J., U. S. Seal, Y. Cohen, E. D. Plotka, and C. S. Asa. 1991. Characterization of prolactin secretion in gray wolves. Canadian Journal of Zoology 69:1366-1374.

Mech, L. D. 1986. Wolf Population in the Central Superior National Forest, 1967-1985. USDA Forest Service NC-270. North Central Forest Experiment Station, St. Paul, MN. 6 pp.

Mech, L. D., L. G. Adams. T. J. Meier, J. W. Burch, and B. W. Dale. 1998. The wolves of Denali. University of Minnesota Press, MN. 227 pages.

Mech, L. D., and R. O. Peterson. 2003. Wolf-prey relations. Pages 131-160 *in* L. D. Mech, and L. Boitani, editors. Wolves: Behavior, ecology, and conservation. University of Chicago Press. 448 pp.

Meier, T. J. 2009. Vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Denali National Park and Preserve, Central Alaska Network: 2009 report. Natural Resource Data Series. NPS/CAKN/NRDS—2009/009. National Park Service, Fort Collins, CO.

Meier, T. J., J. W. Burch, D. Wilder, and M. Cook. 2009. Wolf monitoring protocol for Denali National Park and Preserve, Yukon-Charley Rivers National Preserve and Wrangell-St. Elias National Park and Preserve, Alaska. Natural Resource Report. NPS/CAKN/NRRR—2009/168. National Park Service, Fort Collins, CO.

Miller, B., B. Dugelby, D. Foreman, C. Martinez del Rio, R. Noss, M. Phillips, R. Reading, M. E. Soulé, J. Terborgh, and L. Willcox. 2001. The importance of large carnivores to healthy ecosystems. Endangered Species Update 18:202-210.

National Park Service (NPS). 2003. Subsistence management plan. Unpublished report Denali National Park and Preserve, Denali Park, AK.

National Park Service (NPS). 2007. Wolf-human conflict management plan. Denali National Park and Preserve. Denali National Park and Preserve, Denali Park, AK. 85 pp.

National Park Service (NPS). 2010. Are wolf viewing opportunities at risk? Fact sheet. Denali National Park and Preserve, Denali Park, AK. 2 pp. Available at http://www.nps.gov/dena/naturescience/upload/wolfbuffer2010.pdf (accessed January 2013).

National Park Service (NPS). 2013. Wolf program review, January 2013. Denali National Park and Preserve. Denali Park, Alaska. 16 pp. Available at http://www.nps.gov/dena/naturescience/upload/WolfReview2013-2.pdf (accessed September 2014).

Ripple, W. J., and R. L. Beschta. 2003. Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National park. Forest Ecology and Management 184:299-313.

Seal, U. S., E. D. Plotka, J. M. Packard, and L.D. Mech. 1979. Endocrine correlates of reproduction in the wolf. 1. Serum progesterone, estradiol and LH during the estrous cycle. Biology of Reproduction 21:1057-1066.

U. S. Congress. 1980. Alaska National Interest Lands Conservation Act, Public Law 96-487, DEC. 2, 1980 (94 STAT. 2371). Available at http://www.r7.fws.gov/asm/anilca/toc.html (accessed January 2013).

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, CA.

Wolstad, T., K. Beckmen, C. Gardner, F. Huettmann, and K. Hundertmark. 2009. Lousy wolves: Distribution and habitat assessment of *Trichodectes canis*, an invasive ectoparasite of Alaskan gray wolves. Poster presented at the Northwest Section meeting of The Wildlife Society, Fairbanks, AK.

Zarnke, R. L., and W. B. Ballard. 1987. Serological survey for selected microbial pathogens of wolves in Alaska, 1975-1982. Journal of Wildlife Diseases 23:77-85.

Zarnke, R. L., J. Evermann, J. M. VerHoef, M. E. McNay, R. D. Boertje, C. L. Gardner, L. G. Adams, B. W. Dale, and J. W. Burch. 2001. Serologic survey for canine coronavirus in wolves from Alaska. Journal of Wildlife Diseases 37:740-745.

Appendix A. Figures and Tables.

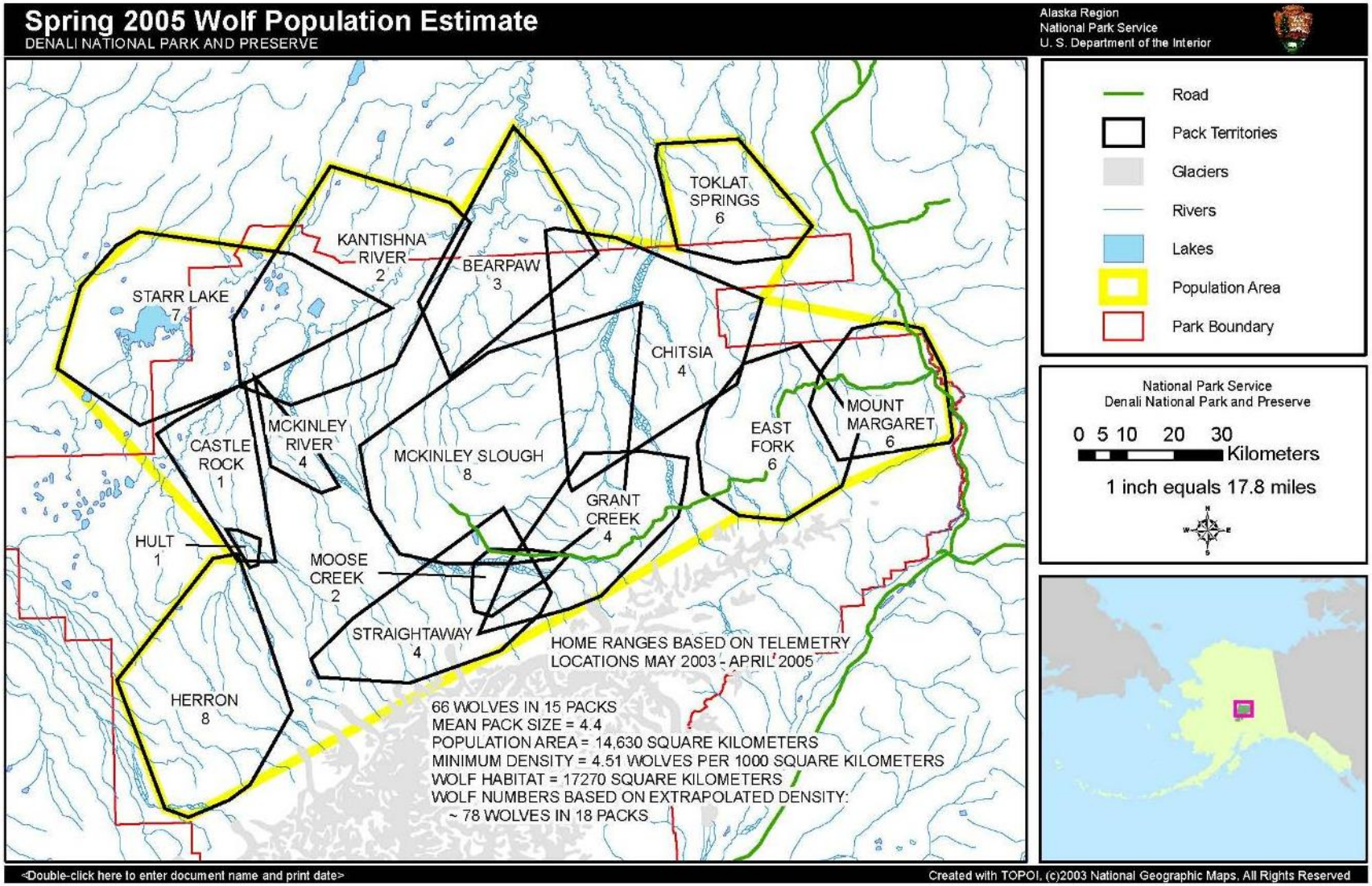


Figure A.1. Wolf pack territories and population estimate for Denali National Park and Preserve, 2005.

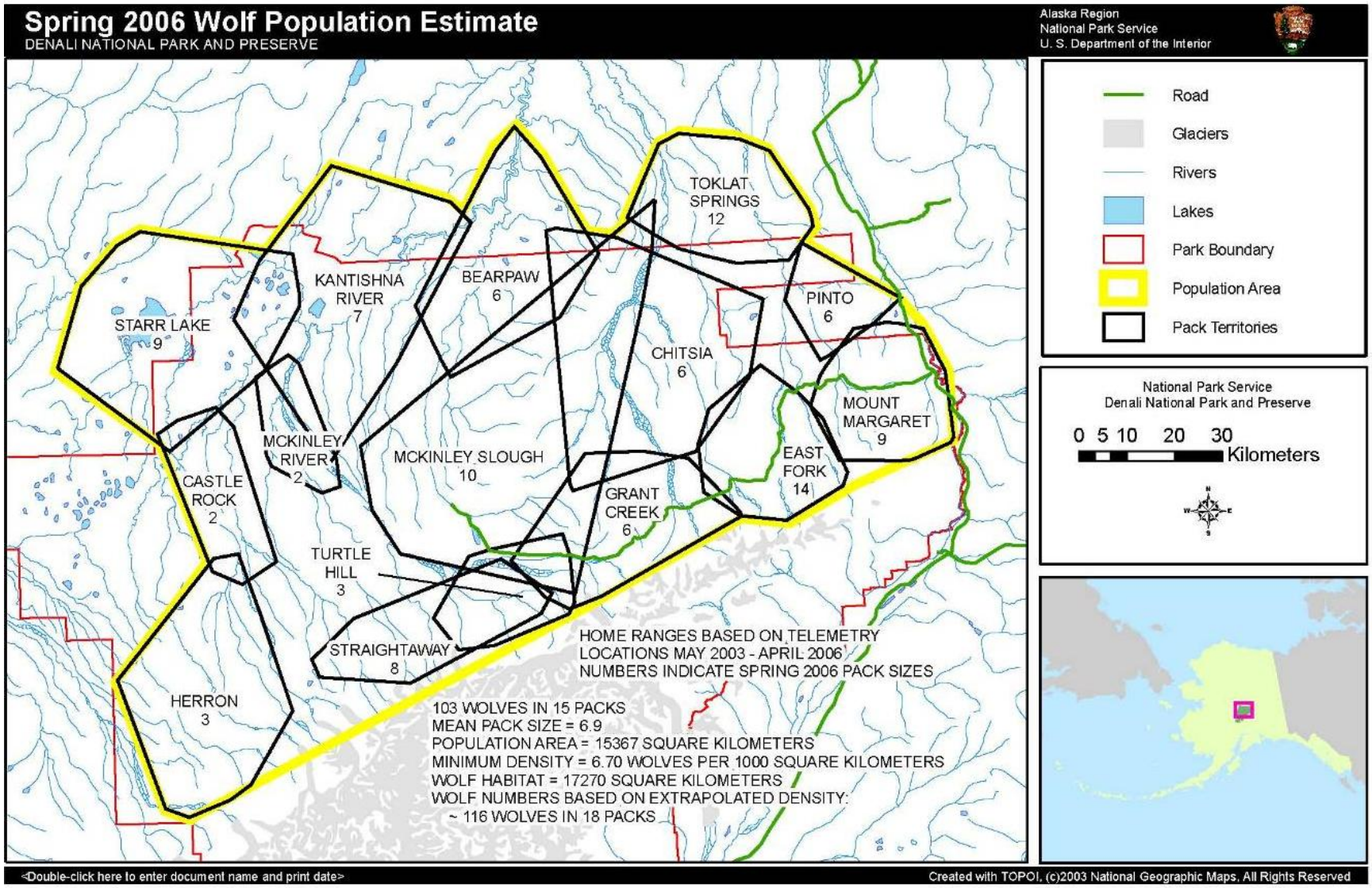


Figure A.2. Wolf pack territories and population estimate for Denali National Park and Preserve, 2006.

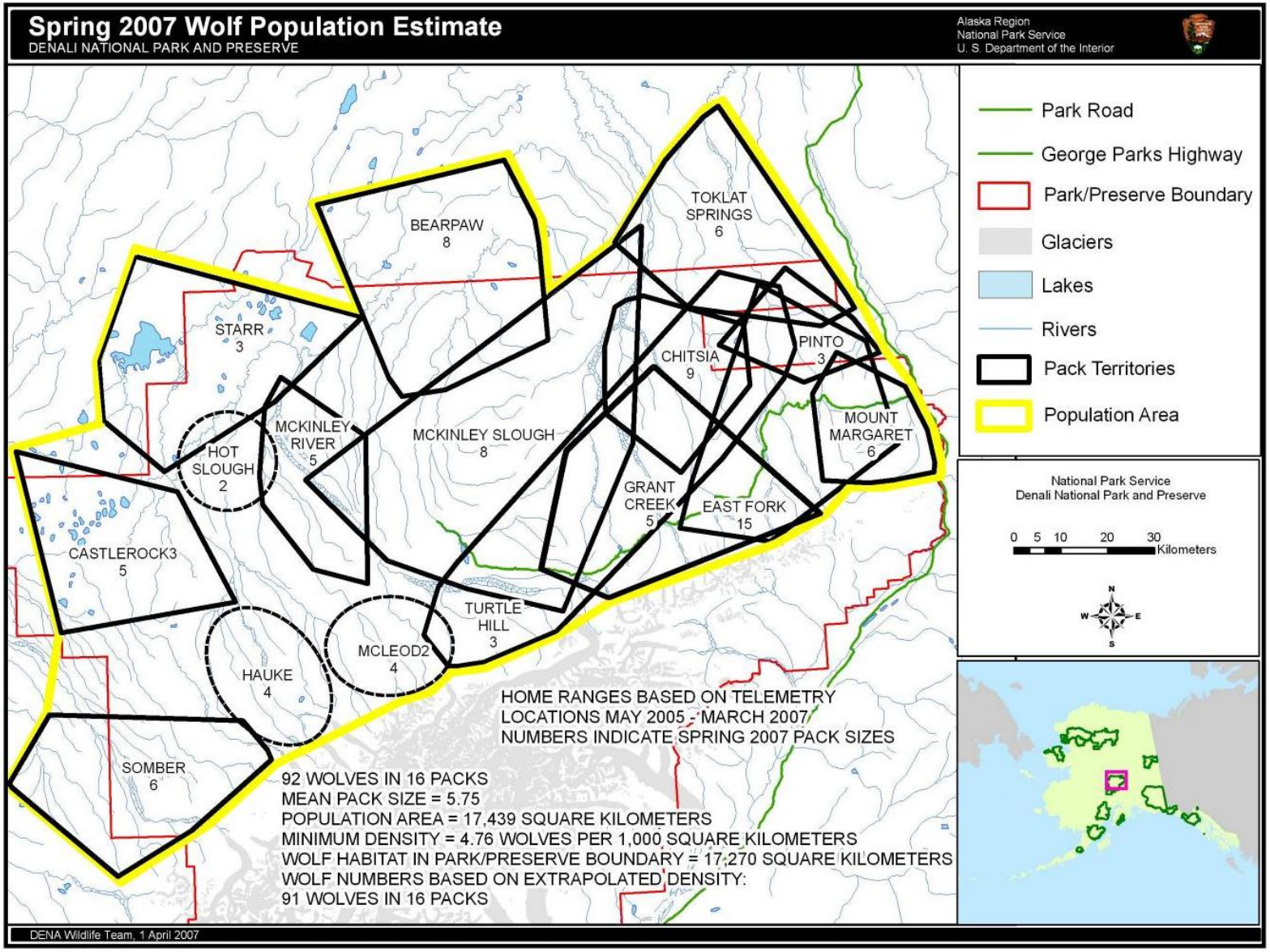


Figure A.3. Wolf pack territories and population estimate for Denali National Park and Preserve, 2007.

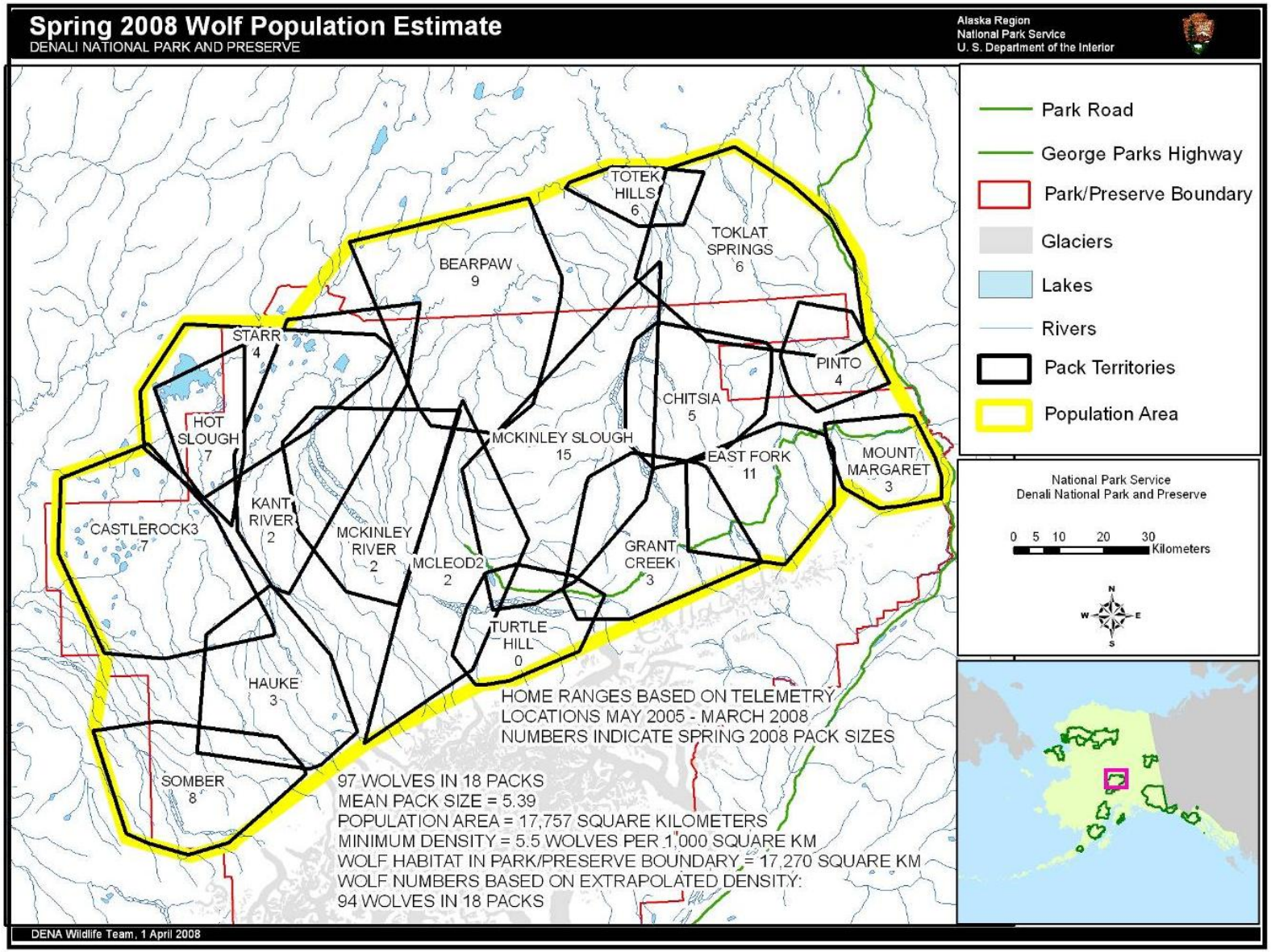


Figure A.4. Wolf pack territories and population estimate for Denali National Park and Preserve, 2008.

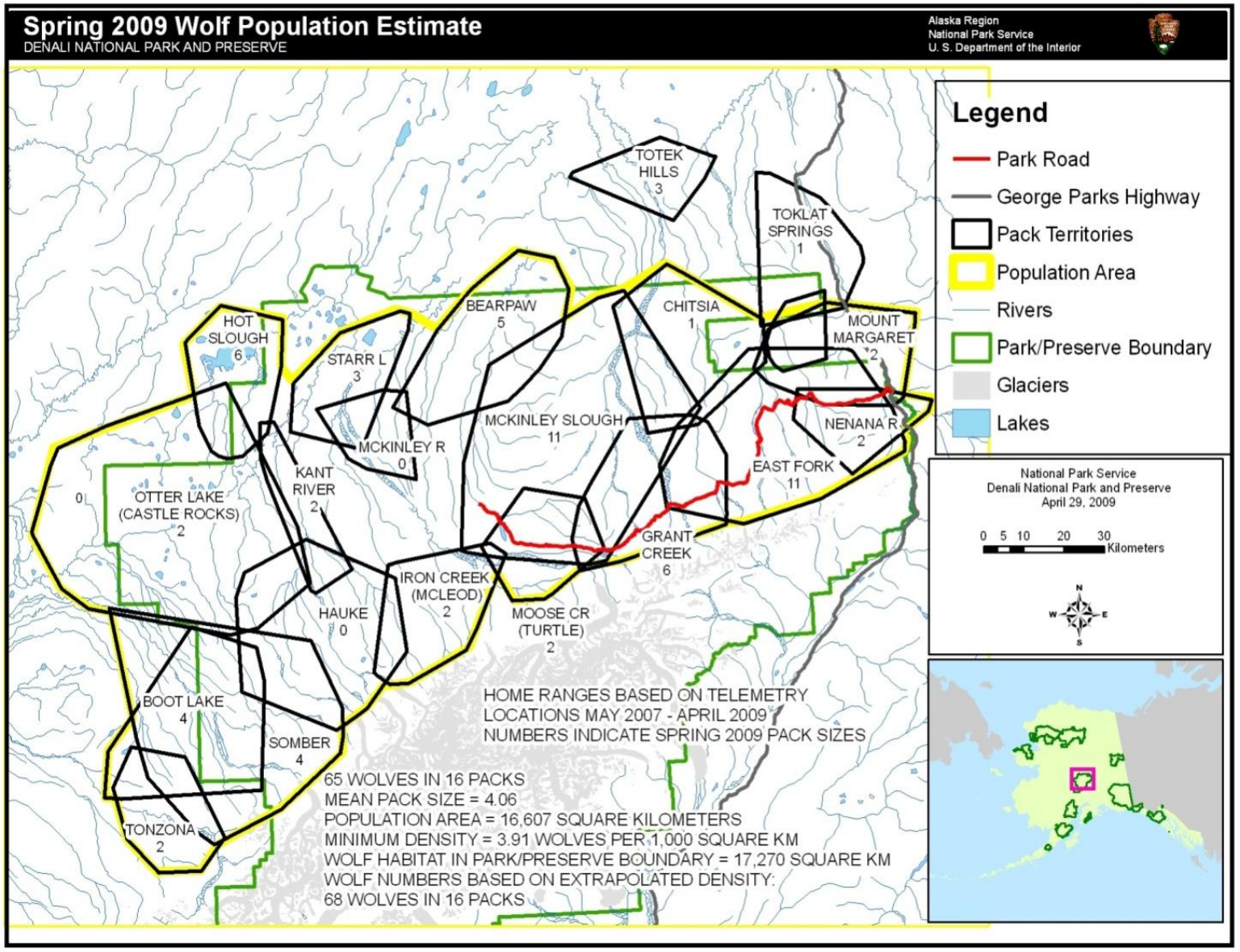


Figure A.5. Wolf pack territories and population estimate for Denali National Park and Preserve, 2009.

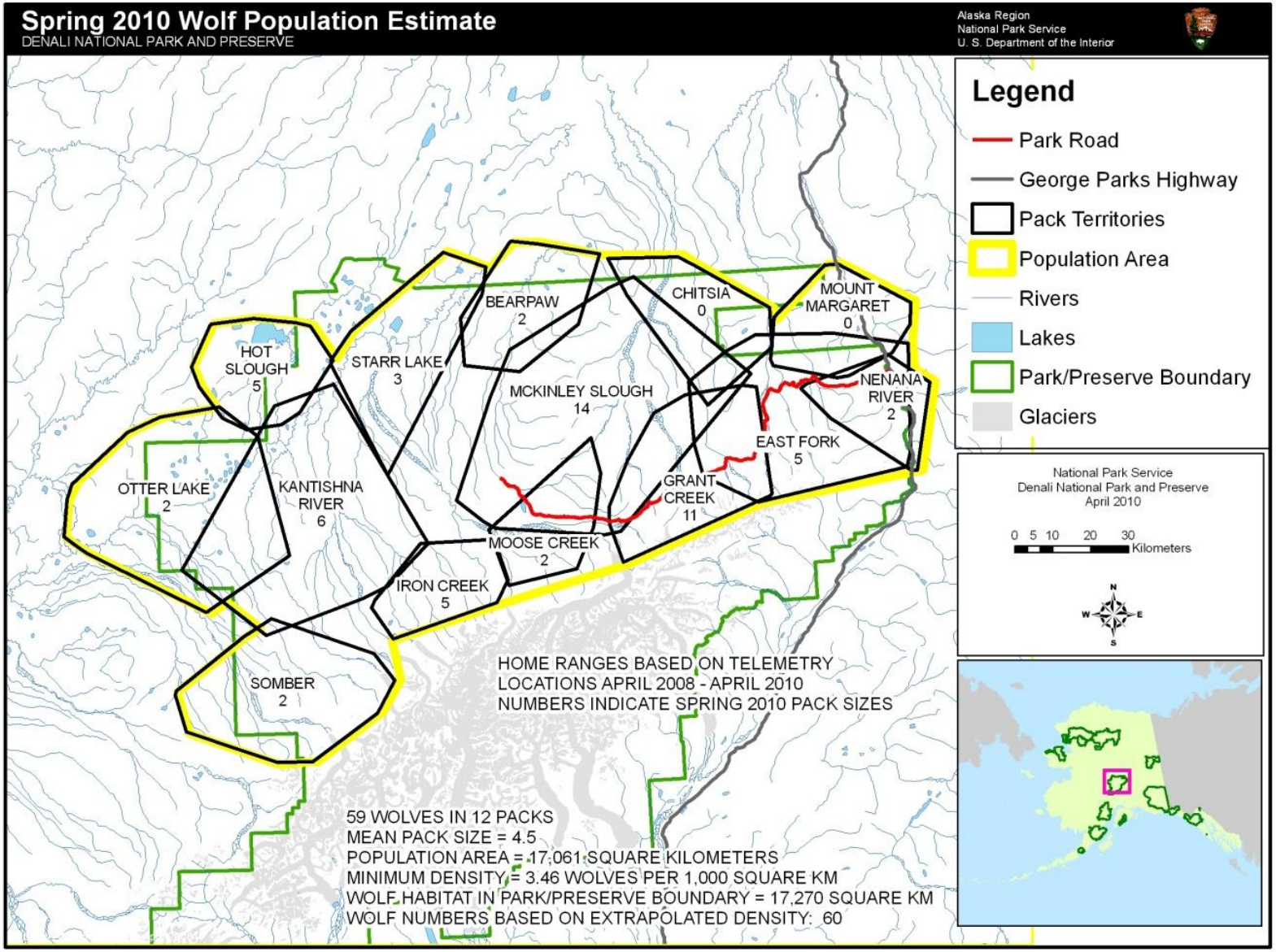


Figure A.6. Wolf pack territories and population estimate for Denali National Park and Preserve, 2010.

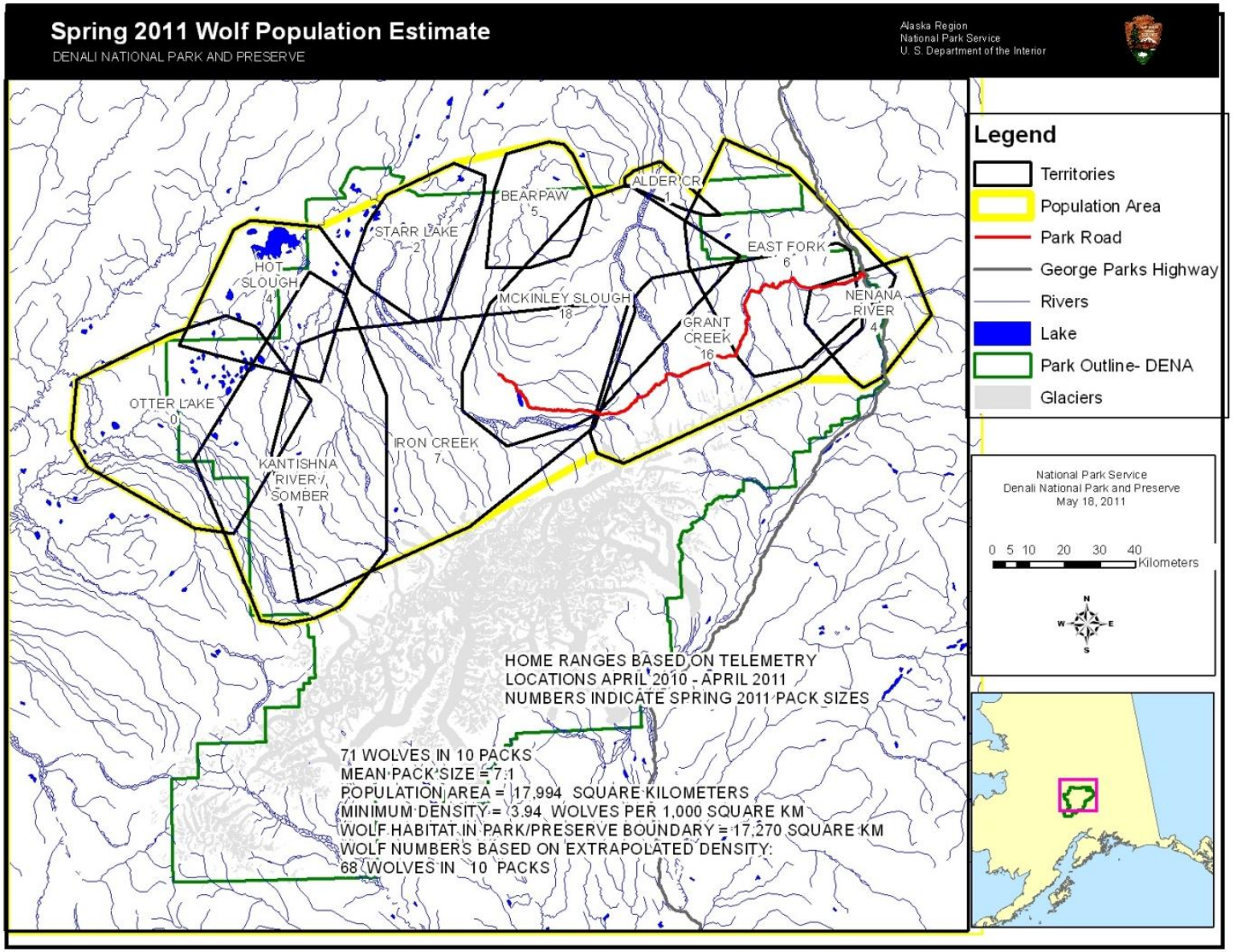


Figure A.7. Wolf pack territories and population estimate for Denali National Park and Preserve, 2011.

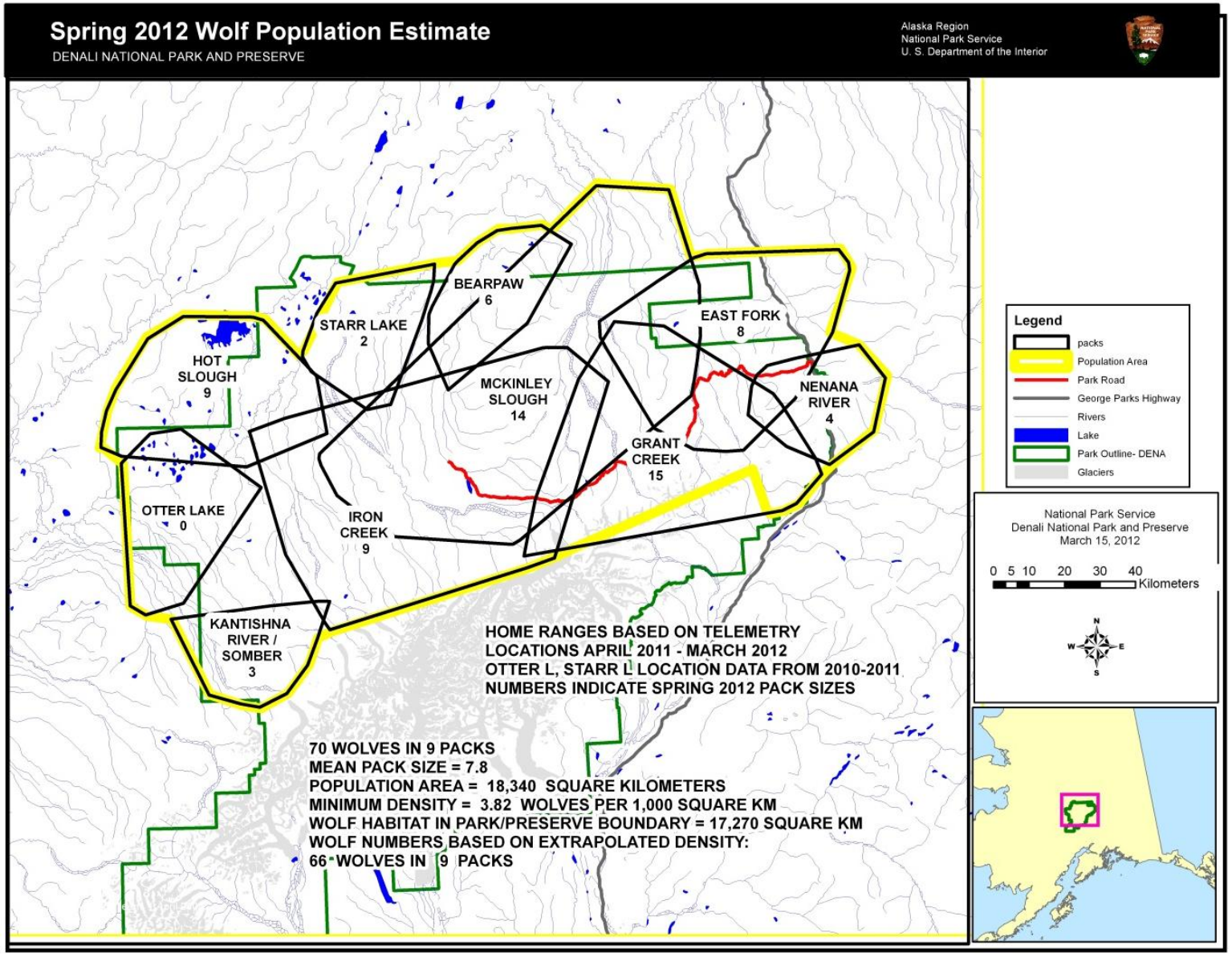


Figure A.8. Wolf pack territories and population estimate for Denali National Park and Preserve, 2012.

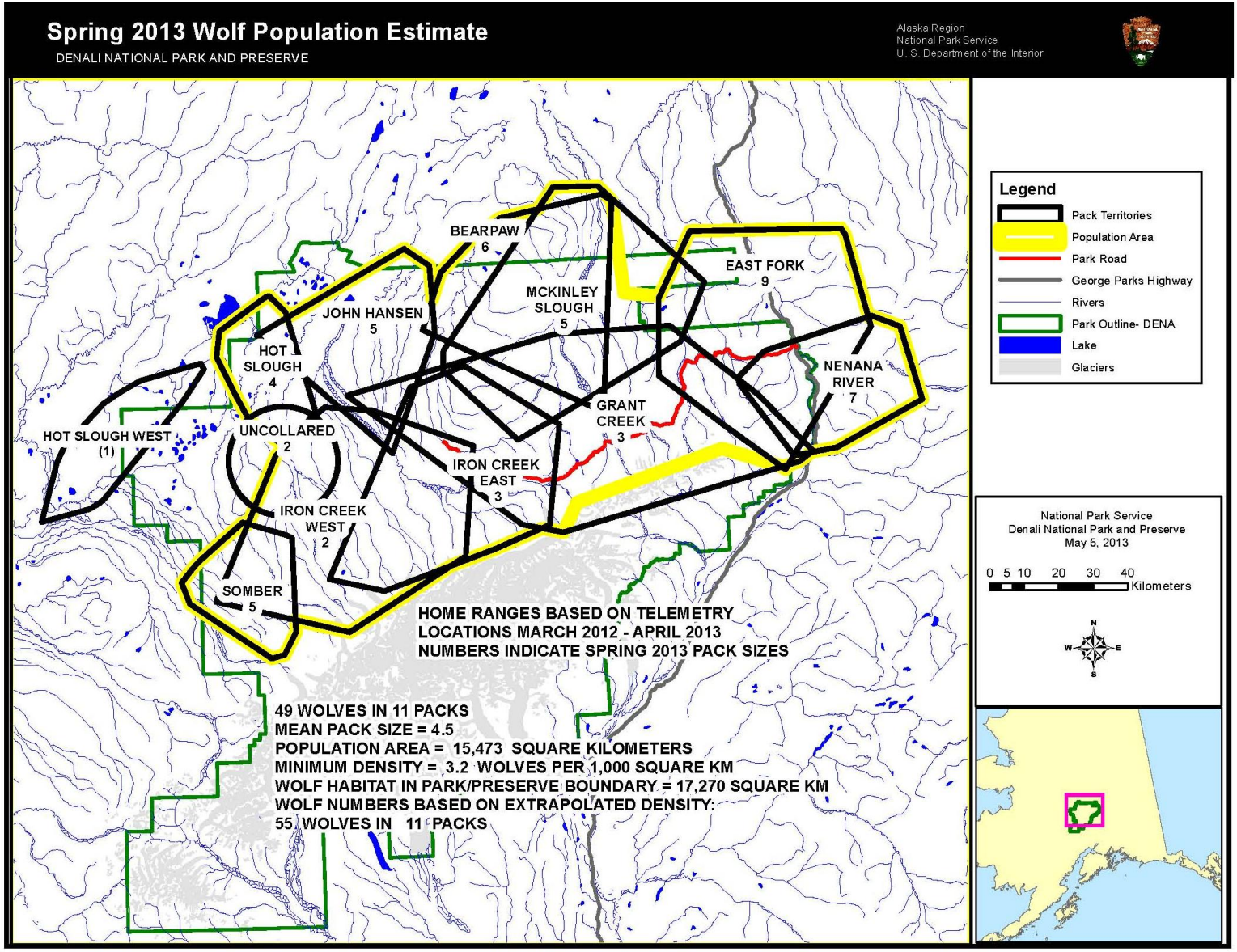


Figure A.9. Wolf pack territories and population estimate for Denali National Park and Preserve, 2013.

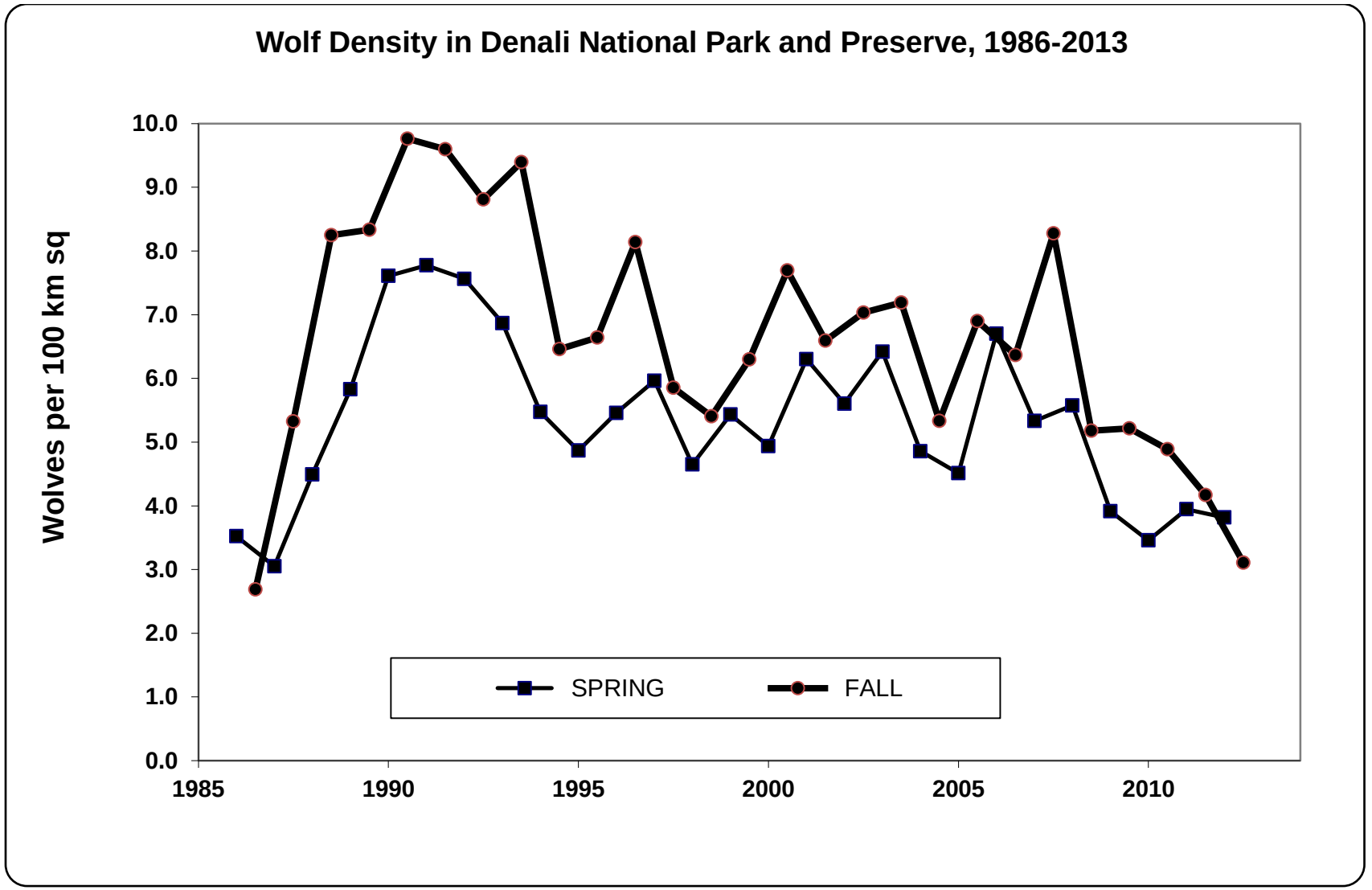


Figure A.10. Spring and fall wolf density estimates, Denali National Park and Preserve, 1986-2013.

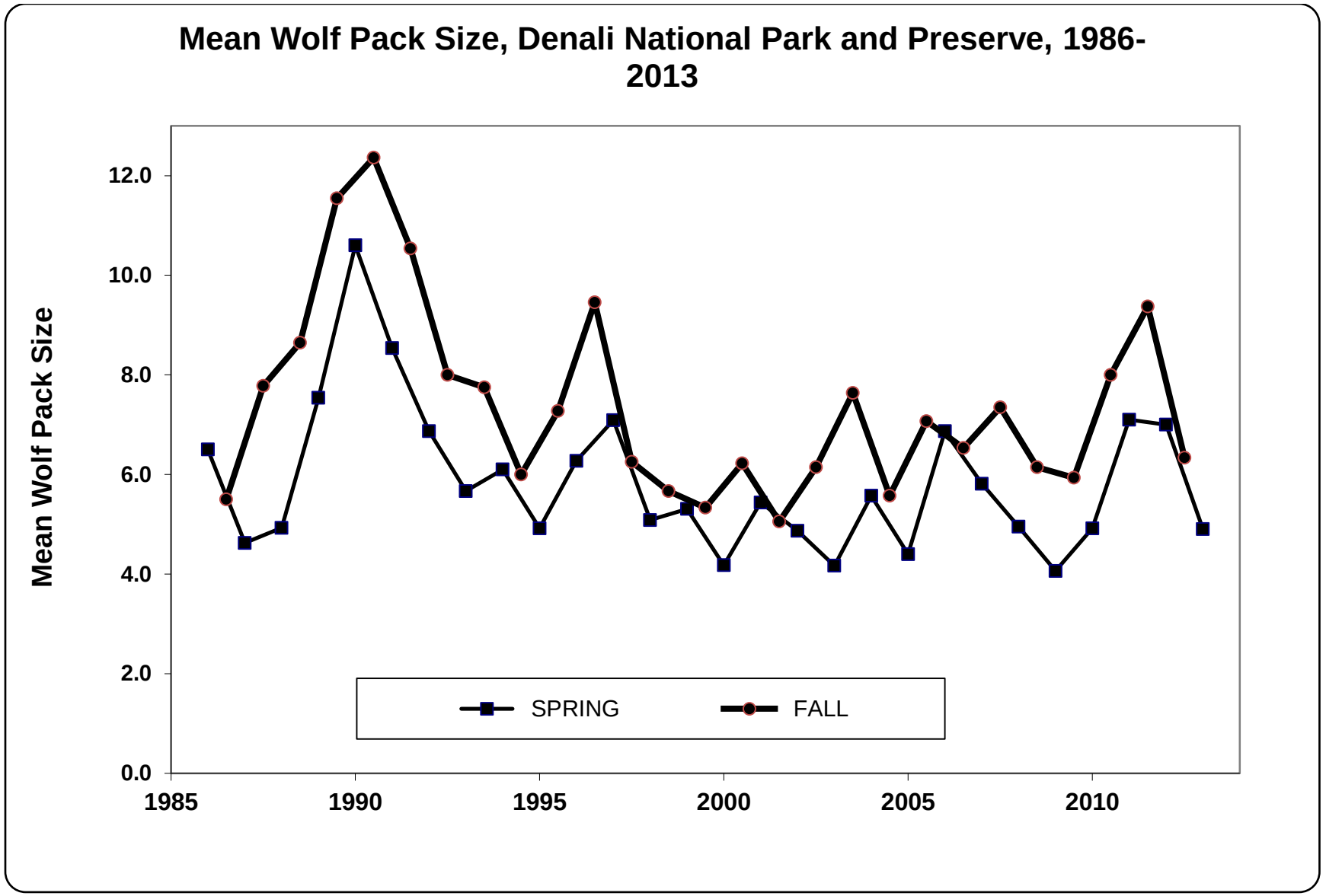


Figure A.11. Spring and fall mean pack size estimates, Denali National Park and Preserve, 1986-2013.

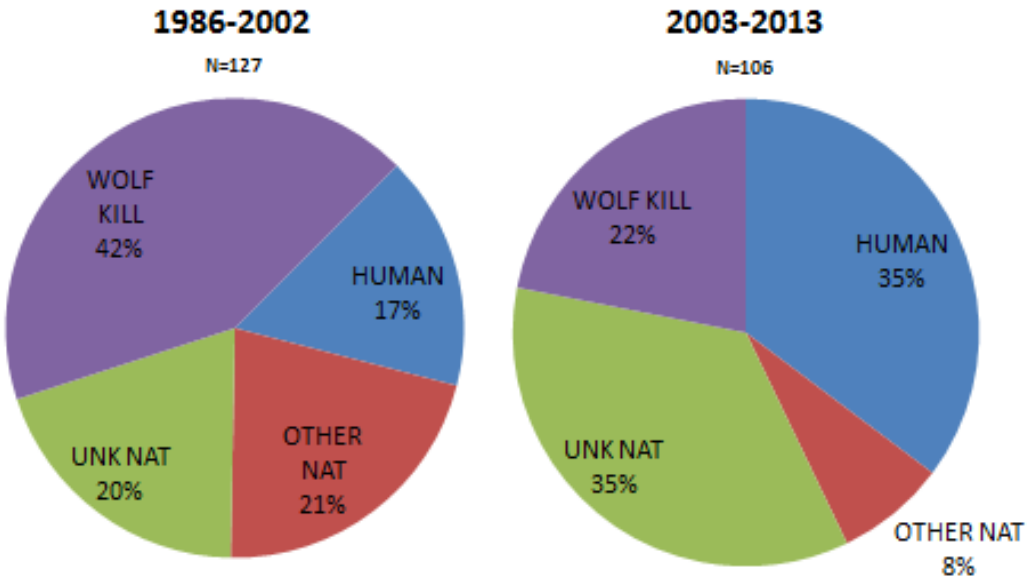


Figure A.12. Sources of mortality of radio-collared wolves for two time periods, Denali National Park and Preserve, Alaska, 1986-2013.

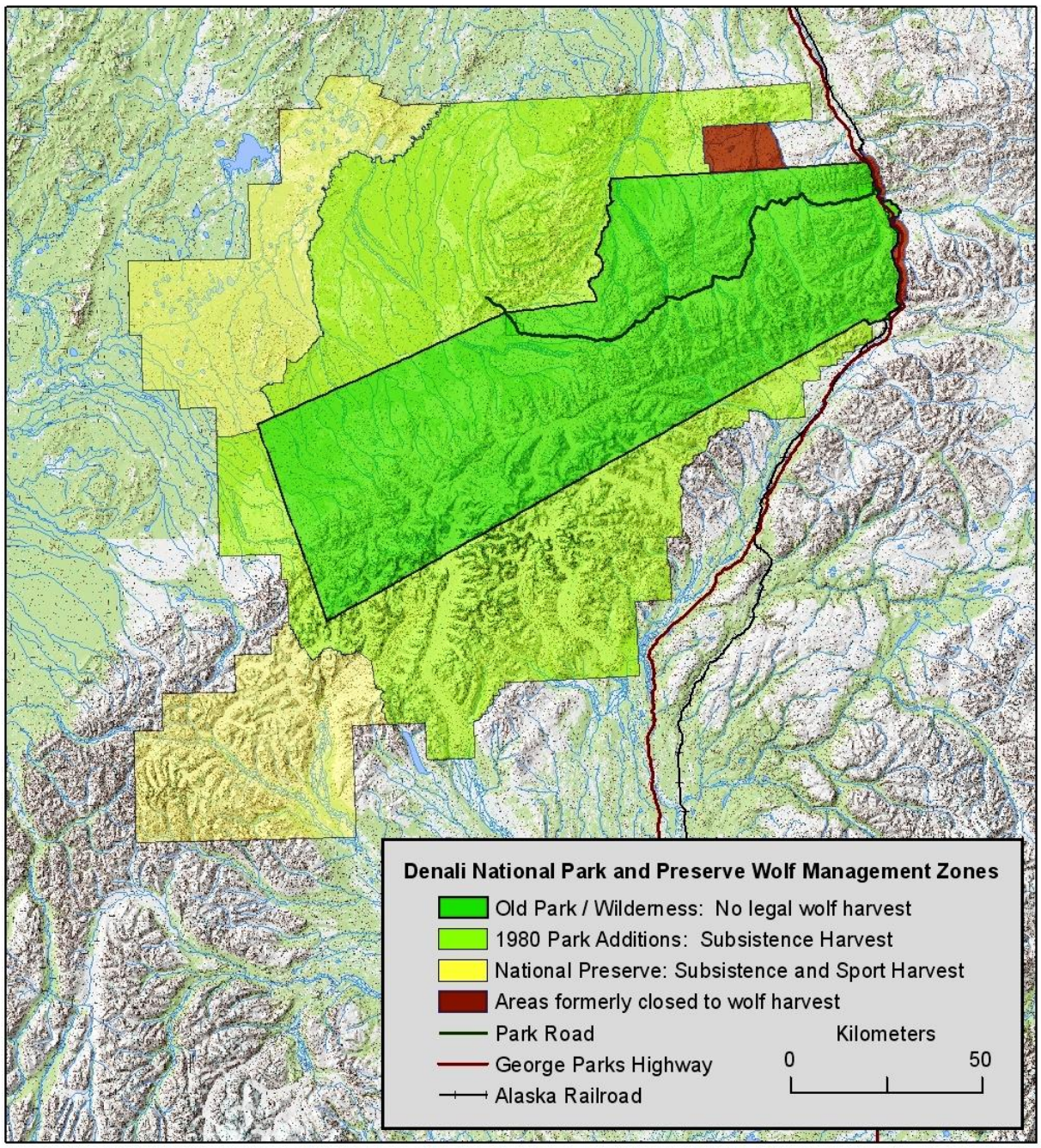


Figure A.13. Denali National Park and Preserve, showing areas of differing wolf management.

Table A.1. Early-winter (fall) density of wolves, Denali National Park and Preserve, 1986-2012.

Year	Number of Packs Monitored	Total Wolves in Packs Monitored	Mean Pack Size	Combined Area of Monitored Packs (KM^2)	Estimated Density (Wolves/1000 KM^2)	Population Estimate Inside the Park*
1986	4	22	5.5	8,180	2.69	46
1987	9	70	7.8	13,150	5.32	92
1988	14	121	8.6	14,670	8.25	142
1989	11	127	11.5	15,240	8.33	144
1990	11	136	12.4	13,930	9.76	169
1991	13	137	10.5	14,275	9.60	166
1992	15	120	8.0	13,620	8.81	152
1993	12	93	7.8	9,900	9.39	162
1994	12	72	6.0	11,145	6.46	112
1995	11	80	7.3	12,045	6.64	115
1996	11	104	9.5	12,776	8.14	141
1997	12	75	6.3	12,808	5.86	101
1998	12	68	5.7	12,578	5.41	93
1999	15	80	5.3	12,699	6.30	109
2000	18	112	6.2	14,554	7.70	133
2001	18	91	5.1	13,802	6.59	114
2002	14	86	6.1	12,226	7.03	121
2003	11	84	7.6	11,682	7.19	124
2004	14	78	5.6	14,630	5.33	92
2005	15	106	7.1	15,367	6.90	119
2006	17	111	6.5	17,439	6.37	110
2007	20	147	7.4	17,757	8.28	143
2008	14	86	6.1	16,607	5.18	89
2009	15	89	5.9	17,061	5.22	90
2010	11	88	8.0	17,994	4.89	84
2011	8	75	9.4	17,994	4.17	72
2012	9	57	6.3	18,340	3.11	54

**Population estimate inside the park*= calculated wolf density across an estimated 17,270 square km of potential habitat within park boundaries, north of the Alaska Range.

Table A.2. Late-winter (spring) density of wolves, Denali National Park and Preserve, 1986-2013.

Year	Number of Packs Monitored	Total Wolves in Packs Monitored	Mean Pack Size	Combined Area of Monitored Packs (KM^2)	Estimated Density (Wolves/1000 KM^2)	Population Estimate Inside the Park*
1986	4	26	6.5	7,380	3.523	61
1987	8	37	4.6	12,125	3.052	53
1988	14	69	4.9	15,355	4.494	78
1989	13	98	7.5	16,810	5.830	101
1990	10	106	10.6	13,930	7.609	131
1991	13	111	8.5	14,275	7.776	134
1992	15	103	6.9	13,620	7.562	131
1993	12	68	5.7	9,900	6.869	119
1994	10	61	6.1	11,145	5.473	95
1995	12	59	4.9	12,120	4.868	84
1996	11	69	6.3	12,640	5.459	94
1997	11	78	7.1	13,080	5.963	103
1998	12	61	5.1	13,121	4.649	80
1999	13	69	5.3	12,699	5.433	94
2000	17	71	4.2	14,378	4.938	85
2001	16	87	5.4	13,802	6.303	109
2002	15	73	4.9	13,026	5.604	97
2003	18	75	4.2	11,682	6.420	111
2004	14	78	5.6	16,061	4.856	84
2005	15	66	4.4	14,630	4.511	78
2006	15	103	6.9	15,367	6.703	116
2007	16	93	5.8	17,439	5.333	92
2008	20	99	5.0	17,757	5.575	96
2009	16	65	4.1	16,607	3.914	68
2010	12	59	4.9	17,061	3.458	60
2011	10	71	7.1	17,994	3.946	68
2012	10	70	7.0	18,340	3.817	66
2013	11	49	4.5	15,473	3.187	55

**Population estimate inside the park*=calculated wolf density estimate across an estimated 17,270 square km of potential habitat within park boundaries, north of the Alaska Range.

Table A.3. Wolf pack sizes, Denali National Park and Preserve, 2007-2013.

Pack	2007		2008		2009		2010		2011		2012		2013	
	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall
BEARPAW	8	10	9	5	5	2	2	6	5	6	6	8	5	
BOOT LAKE		1	(2)	2	4	3	(3)	(8)	(9)					
CASTLE ROCKS	5	7	7	2	0									
CHITSIA	9	11	5	7	1	0								
EAST FORK	15	15	11	16	11	12	5	11	6	10	8	13	8	
GRANT CREEK	5	5	3	6	6	14	11	16	16	13	15	5	3	
HAUKE	4	4	3	0										
HOT SLOUGH	2	7	7	8	6	7	5	3	4	10	9	3	4	
IRON CREEK					2	6	5	9	7	8	9			
IRON CREEK EAST												3	3	
IRON CREEK WEST												7	2	
JOHN HANSEN												8	5	
KANTISHNA RIVER	1	1	2	5	2	6	6	8	0					
MCKINLEY RIVER	5	10	2	0										
MCKINLEY SLOUGH	8	15	15	14	11	15	14	19	18	15	14	5	5	
MCLEOD 2	4	6	2	0										
MOOSE CREEK					2	2	2	0						
MT MARGARET	6	7	3	2	2	5	0	0						
NENANA RIVER					2	6	2	5	4	7	4	8	7	
OTTER LAKE					2	2	2	3	0	?	0			
PINTO	3	10	4	0										
SAVAGE		2	2	6	0									
SOMBER	6	11	8	8	4	2	2	6	7	6	3	6	5	
STARR LAKE	3	6	4	3	3	6	3	3	3	2	2	0		
SQUEEZE													2**	
TOKLAT SPRINGS	6	9	6	(5)	(1)	(3)	(3)	(3)	0		?	(5)	(2)	
TONZONA		(1)	(2)	2	2	1	0	0						
TOTEK HILLS		6	6	(4)	(3)	0	0	0	0					
TURTLE HILL	3	4	0											
UNKNOWN												(4)	(2)	
PACKS	17	20	19	18	18	17	15	15	14	9	10	10	11	
TOTAL WOLVES	93	147	99	86	65	89	59	89	71	77	70	66	49	
AREA IN KM^2	17,439	17,757	17,757	16,607	16,607	17,061	17,061	17,994	17,994	17,994	18,340	18340	15,473	
WOLVES/1000 KM^2	5.33	8.28	5.58	5.18	3.91	5.22	3.46	4.95	3.95	4.28	3.82	3.60	3.17	
EST WOLVES IN PARK*	92	143	96	89	68	90	60	85	68	74	66	62	55	

* *Population estimate inside the park* =calculated wolf density estimate across an estimated 17,270 square km of potential habitat within park boundaries, north of the Alaska Range. ** Not collared.

Peripheral packs, with sizes in parentheses, were not included in the density estimate that year.

Table A.4. Wolf captures, Denali National Park and Preserve, 2003-2013.

WOLF	DATE	RECAP	SEX	AGE	COLOR	PACK	STATUS / FATE
0087	03/16/03	Yes	F	Adult ~8	Dark Gray	Kantishna River	Recaptured, recollared
0316	03/16/03	No	M	Adult ~4	Gray	Castle Rocks 2	Killed by wolves
9755	03/16/03	Yes	F	Adult ~6	Light Gray	Pinto	Shot west of Healy
9974	03/16/03	Yes	M	Adult ~2	Dark Gray	Death Valley	Died, unknown natural causes
0092	03/17/03	Yes	F	Adult ~5	Gray	Mount Margaret	Killed by wolves
0317	03/17/03	No	F	Adult ~3	Black	Castle Rocks 2	Snared near Lake Minchumina
0079	03/18/03	Yes	M	Adult ~6	Blue	Muddy River	Died, unknown natural causes
0089	03/18/03	Yes	M	Adult ~6	Gray	McKinley Slough	Missing
0104	10/26/03	Yes	M	Adult ~4	Gray	Mount Margaret	Snared west of Healy
0318	10/26/03	No	F	Adult ~4	Gray	East Fork	Snared west of Healy
0103	10/27/03	Yes	F	Adult ~4	Gray	Grant Creek	Collar failed
0319	10/27/03	No	M	Adult ~2	Gray	Death Valley	Trapped west of Healy
0320	10/28/03	No	F	Yearling	Gray	McKinley Slough	Missing
0321	10/28/03	No	F	Adult ~4	Gray	Straightaway	Starved
0322	10/28/03	No	F	Yearling	Black	Kantishna River	Missing
0401	02/18/04	No	F	Yearling	Gray	Muddy River	Shot west of Healy
0402	02/18/04	No	F	Adult ~5	Blue	Chitsia	Recaptured, recollared
0403	03/06/04	No	F	Adult ~4	Gray	Turtle Hill	Collar failed
0102	03/07/04	Yes	F	Adult ~6	Light Gray	100 Mile	Died, probably starved
0404	03/07/04	No	M	Adult ~5	Light Gray	100 Mile	Starved
0405	03/07/04	No	F	Yearling	Gray	100 Mile	Died of unknown causes
0406	03/07/04	No	F	Adult ~5	Gray	Herron	Collar chewed off
0407	03/07/04	No	M	Adult ~2	Gray	Herron	Collar chewed off
0408	03/08/04	No	F	Yearling	Gray	Mount Margaret	Recaptured, recollared
0409	03/08/04	No	F	Adult ~4	White	Toklat Springs	Recaptured, recollared
0410	03/08/04	No	M	Yearling	Gray	Toklat Springs	Shot on lower Toklat River
0411	03/08/04	No	F	Yearling	Gray	Chitsia	Recaptured, recollared
0412	03/08/04	No	F	Adult ~4	Gray	McKinley River	Died, unknown natural causes
0413	03/08/04	No	M	Pup	Gray	Castle Rocks 2	Died, unknown natural causes
0087	03/09/04	Yes	F	Adult ~9	Blue	Kantishna River	Starved
0414	03/09/04	No	M	Adult ~4	Black	Bearpaw	Recaptured, recollared
0415	03/09/04	No	F	Adult ~3	Gray	Bearpaw	Recaptured, recollared
0416	03/09/04	No	F	Pup	Gray	Starr Lake	Missing
0411	03/04/05	Yes	F	Adult ~2	Gray	Chitsia	Collar failed
0414	03/04/05	Yes	M	Adult ~5	Black	Bearpaw	Recaptured, recollared
0501	03/04/05	No	M	Adult ~3	Gray	Mount Margaret	Recaptured, recollared
0502	03/04/05	No	F	Yearling	Gray	Mount Margaret	Died, unknown natural causes
0503	03/04/05	No	M	Adult ~2	Gray	Chitsia	Recaptured, recollared
0504	03/04/05	No	M	Adult ~8	White	Toklat Springs	Shot on lower Toklat River
0505	03/05/05	No	M	Adult ~3	Gray	McKinley River	Recaptured, recollared
0101	03/06/05	Yes	F	Adult ~6	Gray	Kantishna River	Killed by wolves
0107	03/06/05	Yes	F	Adult ~6	Gray	McKinley Slough	Killed by wolves
0506	03/06/05	No	M	Adult ~3	Black	Lone (Hult Creek)	Starved
0507	03/06/05	No	M	Adult ~3	Black	Kantishna River	Killed by wolves
0508	03/07/05	No	F	Adult ~4	Gray	Turtle Hill	Killed by wolves

Table A.4. Wolf captures, Denali National Park and Preserve, 2003-2013 (continued).

WOLF	DATE	RECAP	SEX	AGE	COLOR	PACK	STATUS / FATE
0408	02/01/06	Yes	F	Adult ~3	Gray	Mount Margaret	Died from blunt trauma
0601	02/01/06	No	M	Adult ~2	Black	Turtle Hill	Trapped west of Healy
0403	02/08/06	Yes	F	Adult ~6	Light Gray	Turtle Hill	Recaptured, recollared
0602	02/09/06	No	F	Yearling	Gray	Toklat Springs	Shot on lower Teklanika River
0605	02/23/06	No	F	Pup	Black	East Fork	Shot near Cantwell
0606	02/23/06	No	M	Adult ~3	Gray	Pinto	Died of unknown causes
0607	02/23/06	No	F	Adult ~5	Gray	Pinto	Shot west of Healy
0103	02/24/06	Yes	F	Adult ~6	Gray	Grant Creek	Killed by wolves
0215	02/24/06	Yes	M	Adult ~6	Gray	Grant Creek	Killed by wolves
0214	02/28/06	Yes	F	Adult ~7	Blue	McKinley River	Killed by wolves
0505	02/28/06	Yes	M	Adult ~4	Gray	McKinley River	Recaptured, recollared
0608	02/28/06	No	F	Adult ~4	Silver	Starr Lake	Drowned
0609	02/28/06	No	F	Adult ~3	Black	Starr Lake	Recaptured, recollared
0610	03/01/06	No	F	Adult ~4	Gray	Somber	Recaptured, recollared
0611	03/01/06	No	F	Yearling	Gray	Somber-Tonzona	Still being monitored
0612	03/01/06	No	F	Adult ~4	Gray	Castle Rocks 3	Recaptured, recollared
0613	03/01/06	No	M	Adult ~3	Blond	Castle Rocks 3	Missing
0614	03/01/06	No	M	Yearling	Gray	Toklat Springs	Trapped south of Healy
0615	03/11/06	No	M	Adult ~7	White	Straightaway	Killed by wolves
0616	04/17/06	No	M	Pup	Gray	Kantishna River	Trapped in Minto area
0617	04/17/06	No	M	Pup	Black	Kantishna River	Recaptured, recollared
0618	04/17/06	No	F	Adult ~2	Gray	East Fork	Recaptured, recollared
0503	12/11/06	Yes	M	Adult ~4	Gray	Chitsia	Recaptured, recollared
0620	12/11/06	No	F	Yearling	Gray	Chitsia	Trapped north of park boundary
0621	12/11/06	No	F	Yearling	Gray	Toklat Springs	Trapped west of Healy
0622	12/11/06	No	M	Yearling	Gray	Grant Creek	Snared east of park boundary
0701	02/14/07	No	M	Adult ~2	Gray	McKinley Slough	Missing
0702	02/14/07	No	M	Adult ~3	Gray	McKinley Slough	Recaptured, recollared
0703	02/14/07	No	F	Adult ~8	White	Hauke	Killed by wolves
0704	02/14/07	No	M	Adult ~4	Gray	Hauke	Recaptured, recollared
0402	02/27/07	Yes	F	Adult ~8	Gray	Chitsia	Died, unknown natural causes
0409	02/27/07	Yes	F	Adult ~6	White	Pinto	Trapped west of Healy
0705	03/01/07	No	F	Yearling	Light Gray	McLeod 2	Killed by wolves
0706	03/01/07	No	F	Adult ~7	Gray	McLeod 2	Died, unknown natural causes
0707	03/01/07	No	F	Adult ~2	Gray	Lone (Boot Lake)	Still being monitored
0505	03/03/07	Yes	M	Adult ~5	Gray	McKinley River	Died ,unknown natural causes
0708	03/03/07	No	F	Pup	Gray	Somber	Recaptured, recollared
0709	03/03/07	No	F	Pup	Gray	Bearpaw	Collar found near Manley
0710	03/04/07	No	F	Pup	Gray	Somber	Shot west of park boundary
0711	03/04/07	No	M	Pup	Gray	Totek Hills	Shot near lower Teklanika River
0712	03/28/07	No	F	Yearling	Black	East Fork/Savage	Trapped south of Healy
0713	03/28/07	No	M	Pup	Gray	Totek Hills	Died, unknown natural causes
0610	03/29/07	Yes	F	Adult ~6	Gray	Somber	Died, unknown natural causes
0612	03/29/07	Yes	F	Adult ~5	Blue	Castle Rocks 3	Died, unknown natural causes
0714	03/29/07	No	F	Adult ~2	Gray	Hot Slough	Killed by wolves

Table A.4. Wolf captures, Denali National Park and Preserve, 2003-2013 (continued).

WOLF	DATE	RECAP	SEX	AGE	COLOR	PACK	STATUS / FATE
0715	03/29/07	No	M	Adult ~2	Gray	Hot Slough	Died, unknown natural causes
0716	03/29/07	No	M	Adult ~5	Black	Starr Lake	Died, unknown natural causes
0403	11/27/07	Yes	F	Adult ~8	White	Turtle Hill	Died, unknown natural causes
0702	11/27/07	Yes	M	Adult ~4	Gray	McKinley Slough	Recaptured, recollared
0717	11/27/07	No	M	Adult ~5	Silver	East Fork	Recaptured, recollared
0718	11/27/07	No	F	Adult ~5	Light Gray	McKinley Slough	Died, unknown natural causes
0719	11/27/07	No	F	Adult ~2	Gray	Grant Creek	Still being monitored
0720	11/28/07	No	M	Adult ~3	Gray	McLeod 2	Trapped north of park boundary
0721	11/28/07	No	M	Yearling	Gray	Hauke	Dispersed north
0722	11/28/07	No	F	Adult ~3	Black	Kantishna River	Missing
0723	11/29/07	No	M	Adult ~3	Gray	Toklat Springs	Died, unknown causes
0724	11/29/07	No	F	Pup	Gray	Totek Hills	Trapped north of park boundary
0414	03/02/08	Yes	M	Adult ~8	Silver	Bearpaw	Died, unknown natural causes
0415	03/02/08	Yes	F	Adult ~7	Gray	Bearpaw	Still being monitored
0618	03/02/08	Yes	F	Adult ~4	Gray	East Fork	Recaptured, recollared
0801	03/02/08	No	M	Adult ~2	Gray	Kabena	Pack moved north out of area
0704	03/03/08	Yes	M	Adult ~5	Gray	Hauke	Killed by wolves after capture
0802	03/03/08	No	M	Yearling	Gray	Castle Rocks 3	Died, unknown natural causes
0803	03/03/08	No	F	Yearling	Gray	Unk/Fish Camp	Died, unknown natural causes
0609	03/04/08	Yes	F	Adult ~5	Black	Starr Lake	Missing
0804	03/04/08	No	M	Adult ~2	Gray	Starr Lake	Recaptured, recollared
0805	03/04/08	No	F	Pup	Gray	Hot Slough	Still being monitored
0806	03/04/08	No	M	Adult ~2	Gray	Castle Rocks 3	Dispersed, shot in wolf control
0807	04/02/08	No	M	Adult ~3	Gray	Savage	Not collared, last seen 12/08
0501	11/01/08	Yes	M	Adult ~2	Gray	Mount Margaret	Trapped west of Healy
0810	11/01/08	No	F	Adult ~2	Gray	Toklat Springs	Trapped north of park boundary
0811	11/01/08	No	M	Adult ~3	Gray	Grant Creek	Still being monitored
0812	11/01/08	No	F	Adult ~5	Light Gray	McKinley Slough	Still being monitored
0813	11/01/08	No	F	Adult ~7	Black	Mount Margaret	Killed by wolves
0814	11/02/08	No	M	Adult ~7	Dark Gray	Totek Hills	Dispersed North
0815	11/02/08	No	F	Yearling	Yellow gray	Hot Slough	Trapped south of Minchumina
0816	11/02/08	No	F	Adult ~3	Gray	McKinley Slough	Melted ice, drowned at capture
0817	11/03/08	No	M	Yearling	Dark Gray	Somber	Died, unknown natural causes
0818	11/03/08	No	M	Adult ~4	Gray	Tonzona	Shot on Tonzona River
0819	11/04/08	No	M	Adult ~4	Gray	Chitsia	Died, unknown natural causes
0617	02/21/09	Yes	M	Adult ~3	Black	Kantishna River	Recaptured, recollared
0722	02/21/09	Yes	F	Adult ~4	Black	Kantishna River	Died, unknown natural causes
0901	02/21/09	No	F	Yearling	Gray	Hot Slough	Died, unknown natural causes
0902	02/22/09	No	M	Adult ~2	Black	Bearpaw	Dispersed to N Fork Kuskokwim
0903	02/22/09	No	F	Yearling	Gray	Somber	Dispersed to S Fork Kuskokwim
0904	02/22/09	No	M	Adult ~2	Gray	Boot Lake	Still being monitored
0905	02/23/09	No	F	Yearling	Gray	Nenana River	Still being monitored
0906	02/23/09	No	M	Adult ~3	Black	Mount Margaret	Shot NE of Healy
0907	02/23/09	No	F	Adult ~2	Blue	Otter Lake	Died, unknown natural causes
0908	02/23/09	No	F	Adult ~2	Black	Otter Lake	Dispersed to Mucha Lake area

Table A.4. Wolf captures, Denali National Park and Preserve, 2003-2013 (continued).

WOLF	DATE	RECAP	SEX	AGE	COLOR	PACK	STATUS / FATE
0909	02/23/09	No	F	Adult ~2	Gray	Moose Creek	Killed by wolves
0910	02/23/09	No	M	Adult ~2	Gray	Moose Creek	Died, unknown natural causes
0911	02/24/09	No	M	Adult ~3	Gray	Nenana River	Killed by wolves
0702	02/19/10	Yes	M	Adult ~6	Gray	Mckinley Slough	Still being monitored
0804	02/19/10	Yes	M	Adult ~4	Gray	Starr Lake	Snared near Kantishna River
1001	02/19/10	No	F	Pup	Gray	Iron Creek	Still being monitored
1002	02/19/10	No	F	Adult ~5	Light Gray	Iron Creek	Died, unknown natural causes
1003	02/19/10	No	M	Adult ~4	Gray	Otter Lake	Shot at Telida Village
0618	11/27/10	Yes	F	Adult ~7	Gray	East Fork	Still being monitored
0717	11/27/10	Yes	M	Adult ~8	Silver	East Fork	Snared on Toklat River
1004	11/27/10	No	M	Yearling	Gray	Grant Creek	Still being monitored
1005	11/27/10	No	M	Pup	Gray	Unknown	Trapped in Dry Creek
1006	11/29/10	No	F	Pup	Black	Bearpaw	Still being monitored
1007	12/01/10	No	M	Pup	Dark Gray	Nenana River	Died, unknown natural causes
1008	12/01/10	No	F	Yearling	Black	Hot Slough	Still being monitored
1009	12/01/10	No	M	Yearling	Gray	Iron Creek	Still being monitored
1101	03/08/11	No	F	Yearling	Light Gray	East Fork	Still being monitored
1102	03/08/11	No	M	Pup	Black	East Fork	Still being monitored
0811	03/10/11	Yes	M	Adult ~5	Gray	Grant Creek	Still being monitored
1103	03/10/11	No	F	Yearling	Gray	Grant Creek	Still being monitored
1105	03/10/11	No	M	Yearling	Gray	Nenana River	Still being monitored
0617	03/11/11	Yes	M	Adult ~5	Black	Somber	Still being monitored
0708	03/11/11	Yes	F	Adult ~4	Gray	Somber	Still being monitored
1106	03/11/11	No	F	Yearling	Gray	Mckinley Slough	Still being monitored
1107	03/11/11	No	M	Pup	Gray	Mckinley Slough	Still being monitored
1108	03/11/11	No	M	Adult ~3	Gray	Iron Creek	Still being monitored
1109	03/11/11	No	M	Adult ~2	Black	Somber	Still being monitored
0719	03/10/12	Yes	F	Adult~6	Light Gray	Grant Creek	Died, unknown natural causes
1201	03/10/12	No	M	Adult~2	Gray	East Fork	Collar dropped 9/19/2012
1202	03/10/12	No	F	Adult~3	Black	East Fork	Still being monitored
1203	03/10/12	No	F	Yearling	Black	East Fork	Collar dropped 9/19/2012
1204	03/10/12	No	M	Pup	Gray	Grant Creek	Still being monitored
1205	03/10/12	No	F	Adult~4	Gray	Iron Creek East	Still being monitored
0415	03/11/12	Yes	F	Adult~11	Gray	Bearpaw	Died, unknown natural causes
0805	03/11/12	Yes	F	Adult~4	Gray	Hot Slough	Still being monitored
1206	03/11/12	No	M	Adult~3	Black	Bearpaw	Starvation due to paralysis
1207	03/11/12	No	F	Adult~4	Gray	Iron Creek	Still being monitored
1208	03/12/12	No	F	Yearling	Gray	Iron Creek West	Still being monitored
1209	03/13/12	No	F	Adult~5	Gray	Loner	Still being monitored
1210	03/13/12	No	F	Adult~3	Gray	Somber	Still being monitored
1211	03/13/12	No	F	Adult~3	Gray	McKinley Slough	Still being monitored
0811	01/09/13	Yes	M	Adult~6	Light Gray	Grant Creek	Still being monitored
1301	02/03/13	No	F	Adult~2	Gray	Grant Creek	Shot near Cantwell April 2013
1302	02/03/13	No	M	Adult~2	Gray	John Hansen	Still being monitored
1303	02/03/13	No	F	Adult~4	Gray	John Hansen	Still being monitored

Table A.4. Wolf captures, Denali National Park and Preserve, 2003-2013 (continued).

WOLF	DATE	RECAP	SEX	AGE	COLOR	PACK	STATUS / FATE
1304	02/03/13	No	M	Adult~3	Black	Hot Slough	Still being monitored
1305	03/03/13	No	M	Yearling	Black	Somber	Still being monitored
0618	04/03/13	Yes	F	Adult~9	Light Gray	East Fork	Still being monitored
1306	04/03/13	No	M	Adult~3	Gray	McKinley Slough	Still being monitored
1006	04/03/13	Yes	F	Adult~2	Black	Bearpaw	Still being monitored
1307	04/03/13	No	F	Pup	Light Gray	Bearpaw	Still being monitored

Table A.5. Wolf pack denning and recruitment, Denali National Park and Preserve, 2012.

PACK	Denned	Pups
Eastern Region		
East Fork	Yes	4
Grant Creek	No	
McKinley Slough	Yes	1
Nenana River	Yes	4
Western Region		
Bearpaw	Yes	5
Hot Slough	No	
Hot Slough West	Yes	Unknown
Iron East	Yes	Unknown
Iron West	Yes	Unknown
Somber	Yes	3
Boot Lake	NA	

Table A.6. VHF locations per pack, Denali National Park and Preserve, 2012.

PACK	Pack Locations (VHF)
Eastern Region	
East Fork	69
Grant Creek	39
McKinley Slough	43
Nenana River	27
Western Region	
Bearpaw	49
Hot Slough	17
Hot Slough West	2
Iron East	44
Iron West	30
Somber	18
Boot Lake	NA

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 184/127394, December 2014

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov