



Small Mammal Monitoring Protocol for the Central Alaska Network

Protocol Narrative Version 1.0

Natural Resource Report NPS/AKRO/NRR—2018/1741



ON THE COVER: A northern red-backed vole (*Myodes rutilus*) is captured in Denali National Park and Preserve during the Central Alaska Network long-term monitoring program. This is one of three target species studied in the park.
(NPS/MELANIE FLAMME)

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Executive Summary

The National Park Service (NPS) has developed a long-term ecological monitoring program known as “Vital Signs Monitoring” to provide the minimum infrastructure and enable more than 270 national park units, organized into 32 networks nationwide, to identify and implement long-term monitoring of their highest-priority indicators of natural resource condition. The Vital Signs Monitoring Program is a major component of the National Park Service’s strategy to improve park management through greater reliance on scientific information. This protocol details the justification and procedures for Small Mammal monitoring, a Vital Sign selected by the Central Alaska Network (CAKN). The CAKN includes three park units in interior Alaska: Denali National Park and Preserve (DENA), Yukon-Charley Rivers National Preserve (YUCH) and Wrangell-St. Elias National Park and Preserve (WRST) (Figure 1).

The CAKN developed its monitoring program to encompass several trophic levels of park ecosystems so that the program would be as robust as possible to detecting change constituent vital signs (MacCluskie and Oakley 2005). Small mammals, including voles of the genera *Microtus* and *Myodes* (formerly *Clethrionomys*), are useful for long-term monitoring because they consume seeds, fungi and invertebrates, provide a key prey resource for raptors and carnivorous mammals, and play an important ecological role by having the ability to influence species above and below them in the food chain (Boonstra *et al.* 2001; Boutin *et al.* 2001). While they are not highly visible in the boreal forest, their collective biomass contributes a larger proportion to the animal community than that of grizzly bears (Boonstra *et al.* 2001). Consequently, changes in the abundance or density of small mammals may subsequently affect the species that prey upon them. From these data and other studies, we know that population dynamics of small mammals vary across latitudes. Additionally, the relative abundance of small mammal species is directly related to local composition of plant species. Thus, any park-wide changes in weather or plant species composition or primary productivity will likely affect small-mammal distribution and patterns of abundance (Bangs 1984; Hornfeldt *et al.* 1986; Carrier and Krebs 2002; Olofsson *et al.* 2012; Schmidt *et al.* 2017).

The objective of CAKN Small Mammal monitoring project is to:

Document long-term trends in small mammal population dynamics on the DENA Rock Creek legacy plots, including temporal patterns of density and abundance, of three target species of voles, *Myodes* (formerly *Clethrionomys*) *rutilus*, *Microtus oeconomus* and *Microtus miurus*.

The population dynamics of small mammals can be feasibly estimated by small field crews using basic equipment and traveling on foot (Rexstad 1996). Life history characteristics of small mammals, including short life spans, high reproductive rates, and forays of less than 2 miles (4km), cause population numbers to be reflective of local conditions. The combination of these circumstances makes small mammal populations useful for monitoring to detect local changes in boreal ecosystems (Rexstad and Debevec 2008).

Small mammal populations, including the target species of voles (northern red-backed vole, *Myodes* [formerly *Clethrionomys*] *rutilus*, tundra vole, *Microtus oeconomus*, and singing vole, *Microtus*

miurus) are monitored annually in DENA at the Rock Creek legacy plots using mark-recapture methods via live-trapping techniques.

The Small Mammal monitoring protocol consists of a narrative (this document), Data Quality Standards and Standard Operating Procedures (SOPs) that outline specific aspects of the monitoring protocol. The latest versions of the SOPs and additional supporting information can be accessed online at the National Park Service's Central Alaska Network website:

<https://science.nature.nps.gov/im/units/cakn/> and the Integrated Resource Management Applications portal website: <https://irma.nps.gov/Portal>.

Acknowledgments

A cooperative effort was established in 1991 between the NPS Long-term Ecological Monitoring Program (LTEM), Denali National Park and Preserve (DENA), the U. S. Geological Survey (USGS) and the University of Alaska Fairbanks (UAF) to develop a long-term monitoring program of natural resources in DENA. The Small Mammal protocol was launched under this LTEM program and continues today under the current Central Alaska Network (CAKN) Long-term Inventory and Monitoring Program (MacCluskie and Oakley 2005).

Funding and support for Small Mammal monitoring has been provided by U.S. Geological Survey, CAKN, Yukon-Charley Rivers National Preserve, Denali National Park and Preserve, Student Conservation Association (SCA), Alaska Geographic and Murie Science and Learning Center.

We would like to thank Karen Oakely (USGS), Eric Rexstad and Ed Debevec (UAF) for development and implementation of initial data base, study design, survey protocols and several years of data collection. We thank University of Alaska Museum of the North for their continued collaboration in housing loaned archival small mammal voucher specimens collected from this work. Thanks to Andrea Blakesley for serving as our DENA liaison for this work and assisting in the field. We thank Carl Roland and Carol McIntyre (DENA) for their contributions to the development of analytical methods and data analysis. Many thanks to Nick Bywater of the Central Alaska Network for developing the subsequent database, field computer data collection platforms and assistance with downloading annual data. We thank Regan Sarwas for the development of the small mammal data collection observer protocols for Park Observer on the iPad. Many thanks to Sarah Swanson and Patrick Knavel for informal review and editing of this protocol. We are grateful to the scores of dedicated and hard-working student and adult volunteers (VIPs), undergraduates, graduate students, STEP, Student Conservation Association interns, Youth Conservation Corps students, park biologists and biological technicians and partners from agencies and NGOs who have assisted with field work over these 26 years. In particular, we thank Julia Brice, Anna Quist, Sarah Swanson, Patrick Knavel, Tristan Schoemaker, Eliza Lawler, Jenna DiFolco, Will Caldwell and Delaney Vinson-our Denali Smammals Dream Team!

List of Key Acronyms

CAKN:	Central Alaska Network
CLRU:	<i>Clethrionomys rutilus</i> (now <i>Myodes rutilus</i> ; northern red-backed vole)
CV:	Coefficient of Variation
DENA:	Denali National Park and Preserve
I&M:	Inventory and Monitoring Program, NPS
IACUC:	Institute of Animal Care and Use Committee
IRMA:	Integrated Resource Management Applications Data Store
LTEM:	Long-term Ecological Monitoring
MIMI:	<i>Microtus miurus</i> (singing vole)
MIOE:	<i>Microtus oeconomus</i> (tundra vole)
NPS:	National Park Service
NRR:	Natural Resources Report
PI:	Primary Investigator
PIT:	Passive Integrated Transponder tag
QA/QC:	Quality Assurance and Quality Control of survey data
RF1:	Rock Creek Forest Plot 1
RF2:	Rock Creek Forest Plot 2
RR1:	Rock Creek Riparian Plot 1
RR2:	Rock Creek Riparian Plot 2
SOP:	Standard Operating Procedure
SOSP:	<i>Sorex species</i> (shrew species)
UAF:	University of Alaska-Fairbanks
UAM:	University of Alaska Museum of the North

USFWS: U.S. Fish and Wildlife Service
USGS: U.S. Geological Survey
WRST: Wrangell-St. Elias National Park and Preserve
YUCH: Yukon-Charley Rivers National Preserve

Introduction and Objective

Background and History

Knowing the condition of natural resources in national parks is fundamental to the National Park Service (NPS) mission to manage park resources "unimpaired for the enjoyment of future generations." Park managers are confronted with increasingly complex and challenging issues that require broad-based understanding of the status and trends of park resources as a basis for making management decisions and working with other agencies and the public for the long-term protection of park ecosystems. The purpose of natural resource monitoring in parks is to collect scientifically sound information regarding the current status and long-term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems (Fancy *et al.* 2009). Use of monitoring information will improve the ability of park managers to make science-based decisions and address legal and political issues involving parks and park resources for more effective park operations and management. The overarching goals of the NPS monitoring program are to:

1. Determine the status and trends of selected indicators of park ecosystem conditions to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources;
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management;
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments;
4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment; and
5. Provide a means of measuring progress towards performance goals.

This protocol outlines the justification and procedures for Small Mammal monitoring within the Central Alaska Network (CAKN). The CAKN includes three interior Alaska parks: Denali National Park and Preserve (DENA), Yukon-Charley Rivers National Preserve (YUCH) and Wrangell-St. Elias National Park and Preserve (WRST), which collectively represent 21.7 million acres (MacCluskie and Oakley 2005). In the early 1990s, DENA was selected as a prototype park to develop and test methods for monitoring in subarctic parks (Oakley *et al.* 1999; Roland *et al.* 2003). In the original study design for DENA, detection of change in key characteristics of vegetation and animal communities in the park was the fundamental objective. Five representative watersheds spread throughout the park were selected for the original sampling design. Rock Creek, located close to DENA headquarters and in the front country (not wilderness) was administratively and economically feasible for sampling and co-locating monitoring (e.g vegetation, birds, small mammals, weather). The CAKN Small Mammal monitoring program was started as one component of the Denali Long-term Ecological Monitoring program (LTEM), one of ten "prototype" programs for the National Park Service's current nationwide Long-Term Inventory and Monitoring Program. The National Biological Service (predecessor to the U.S. Geological Survey, Biological Resources

Division) also received funding to work cooperatively with DENA and the University of Alaska Fairbanks (UAF) to develop the monitoring program and conduct research for the program's sampling design. The Small Mammal monitoring program at the Rock Creek watershed of DENA has continued since its inception in 1992, and is now in its 26th year. In 2005, NPS assumed primary responsibility for the administration and implementation of small mammal monitoring in DENA as part of CAKN's "Vital Signs" Inventory and Monitoring Program (MacCluskie and Oakley 2005).

Rational for Small Mammal Monitoring

The ability to detect and track resource changes over time and to understand the forces driving those changes are fundamental to accomplishing the NPS's mission of conserving parks unimpaired for future generations. The CAKN developed its monitoring program to encompass several trophic levels of park ecosystems so that the program would be as robust as possible to detecting change wherever it might occur (MacCluskie and Oakley 2005). Small mammals are useful for long-term monitoring because within Denali's ecosystems, voles of the genera *Microtus* and *Myodes* consume seeds, fungi and invertebrates, provide a key prey resource for raptors and carnivorous mammals, and play an important ecological role as year-round resident animals by having the ability to influence species above and below them in the food web (Boonstra *et al.* 2001; Boutin *et al.* 2001). While they are not highly visible in the boreal forest, their collective biomass contributes a larger proportion to the animal community than that of grizzly bears (Boonstra *et al.* 2001). Consequently, changes in the abundance or density of small mammals may subsequently affect the species that prey upon them. From these data and other studies, we know that population dynamics of small mammals may vary with: latitude (Haydon *et al.* 2003), season (Gilbert and Krebs 1991; Stenseth *et al.* 2003), climate (Ims *et al.* 2008), predation (Korpimäki *et al.* 2002; Getz *et al.* 2006), competition (Klemola *et al.* 2002), photoperiod (Halle and Lehmann 1987), age (Boonstra 1994), overgrazing (Klemola *et al.* 2002), density (Stenseth 1999; Schmidt *et al.* 2017), habitat (Getz *et al.* 2006; Reiter and Andersen 2008), plant productivity (Schmidt *et al.* 2017) and year (Bierman *et al.* 2006). However, the drivers for these population fluctuations remain unresolved and highly disputed (see Krebs 1966; Boutin *et al.* 2001; Boonstra and Krebs 2006; Getz *et al.* 2006; Lambin *et al.* 2006; Lima *et al.* 2006; Krebs *et al.* 2012; Schmidt *et al.* 2017). Data from DENA suggest that annual fluctuations in small-mammal populations are strongly related to abiotic factors like weather, climate and timing of snowfall and biotic factors such as primary productivity (Schmidt *et al.* 2017). Additionally, the relative abundance of small mammal species is directly related to local composition of plant species. Thus, any park-wide changes in weather or plant species composition will likely affect small-mammal species composition, distribution and patterns of abundance over time (Bangs 1984; Bierman *et al.* 2006; Getz *et al.* 2006; Hornfeldt *et al.* 1986; Carrier and Krebs 2002; Olofsson *et al.* 2012; Schmidt *et al.* 2017).

Objective

The objective of CAKN Small Mammal monitoring project is to:

Document long-term trends in small mammal populations on the DENA Rock Creek legacy plots, including temporal patterns of density, abundance and examine vole population cycles of

three target species of voles, *Myodes* (formerly *Clethrionomys*) *rutilus*, *Microtus oeconomus* and *Microtus miurus*.

Methods

The original small mammal survey methods were developed in 1992 by USGS, NPS and UAF under the Long-term Ecological Monitoring Program (LTEM) (Rexstad *et al.* 2005). In 2005, the small mammal monitoring was incorporated under new CAKN Vital Signs monitoring program (Oakley and Boudreau 2000; MacCluskie and Oakley 2005). The LTEM Small Mammal protocol (Rexstad *et al.* 2005) was revised over the years 1) to reduce morbidity and mortality of small mammal captures and enhance population estimates 2) to align with permitting requirements, 3) to increase survey efficiency and feasibility and 4) to update and improve field data collection and analytical methods.

The CAKN Small Mammal monitoring protocol herein is based on the LTEM protocol (Rexstad *et al.* 2005) with modifications adopted from: 1) the NPS Arctic Inventory and Monitoring Network's (ARCN) Dall's Sheep Protocol (Rattenbury and Schmidt 2017; <https://irma.nps.gov/DataStore/Reference/Profile/2238929>) and Yellow-billed Loon (Flamme *et al.* 2018; <https://irma.nps.gov/App/Reference/Profile/2216938>) Park Observer protocols (for field data collection on the iPad); and 2) newer analytical methods developed for estimating small mammal density, abundance and distribution (see Schmidt *et al.* 2017). Modifications include:

CAKN Small Mammal monitoring utilizes larger field-crew sizes to get animals out of traps more quickly and mitigate trapping morbidity and mortality (for compliance with Institute of Animal Care and Use Committee (IACUC) and other permitting approvals).

1. CAKN Small Mammal monitoring uses plastic trap covers (started in 2010) to reduce morbidity and mortality of both birds (the covers may act as a deterrent) and small mammals (to minimize animals getting wet and hypothermic over overheated in the traps). This is for compliance with IACUC and other permitting approvals and to enhance live-trapping population estimates. NPS IACUC can be found at: <https://www.nps.gov/orgs/1103/iacuc.htm>.
2. CAKN Small Mammal monitoring has reduced the sampling area and schedule to just one session at the end of summer (targeting the week of August 12) at the four Rock Creek legacy plots as a compromise between cost and adequate survey frequency. This short, one-time sampling window supports assumptions of population closure for the analytical methods used and is sufficient to assess vole abundance, density and assess population cycles (see Schmidt *et al.* 2017, and Data Analysis SOP 10 for details).
3. CAKN Small Mammal monitoring has adopted Park Observer (enterprise data collection app developed by NPS) protocols (data sheets) on the iPad for field data collection, based on the ARCN Dall's Sheep (Rattenbury and Schmidt 2017) and Yellow-billed Loon (Flamme *et al.* 2018) SOPs. Software and hardware used for previous field computers have become obsolete.
4. CAKN Small Mammal monitoring has updated analytical methods. Data analysis procedures are described in detail in SOP 10, Small Mammal Monitoring Data Quality Standards and Schmidt *et al.* 2017. The mark-recapture data generated from live-trapping of the three target species from one session in mid-August annually (1992-2017) were sufficient to estimate

northern red-backed vole abundance, density and assess the amplitude of population cycles. Spatially-explicit capture-recapture models (Royle and Dorazio 2008; Efford et al. 2009; Borchers 2012; Efford and Fewster 2013) fit in a Bayesian hierarchical framework (e.g., Royle and Young 2008; Gardner et al. 2009, 2010; Royle et al. 2009) were employed.

Site Selection

In the early 1990s, DENA was selected as a prototype park to develop and test methods for monitoring in subarctic parks under the Long-term Ecological Monitoring program (LTEM, now I&M program) (Oakley et al. 1999; Roland et al. 2003). In the original study design for DENA, detection of change in key characteristics of vegetation and animal communities in the park was the fundamental objective. Five representative watersheds spread throughout the park were selected for the original sampling design. Rock Creek, located close to DENA headquarters and in the front country (not wilderness) was administratively and economically feasible for sampling and co-locating monitoring (e.g. vegetation, birds, small mammals, weather).

The CAKN Small Mammal monitoring program was started as one prototype study of the original LTEM programs, and it persists to this day under the National Park Service's current nationwide Long-Term Inventory and Monitoring Program. Small mammals have been monitored at the four Rock Creek legacy plots from 1992-2018 (Figure 1). Two of these four plots, RF1 and RR2, have been sampled continuously from 1992-2018 (Table 1).

Table 1. Years of trapping at each Rock Creek legacy plot during the Central Alaska Network Small Mammal monitoring in Denali National Park and Preserve, Alaska, 1992-2018. From 1992-2004, sampling occurred multiple times and throughout the summer. From 2005-2018^a, sampling only occurred during only one session in August on the Rock Creek legacy plots.

Sampling Location	Years Sampled	Distance to Rock Creek	Trapping Configuration	No. Plots	No. Traps Deployed
Rock Creek (RF1)	1992-2018 ^a	~500 m	10x10 m square	1	100
Rock Creek (RF2)	1997-2003, 2005-2018 ^a	~500 m	10x10 m square	1	100
Rock Creek (RR1)	1992- 1993, 1997-2018 ^a	~300 m	10x10 m square	1	100
Rock Creek (RR2)	1992-2018 ^a	~200 m	10x10 m square	1	100

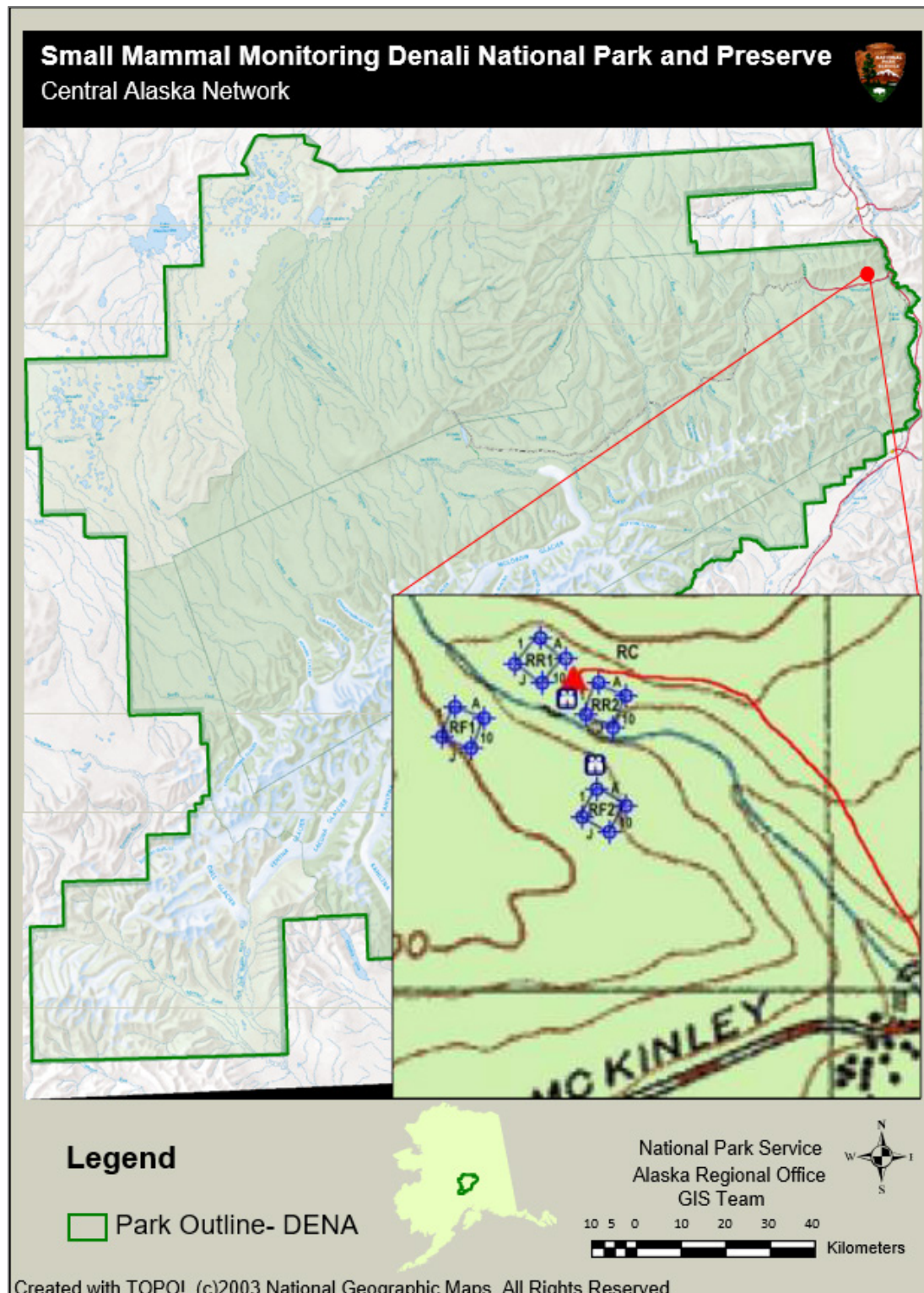


Figure 1. The Central Alaska Network Small Mammal monitoring program has occurred in Denali National Park and Preserve, Alaska, U.S.A., from 1992-2018. The red dot denotes the location of the Rock Creek legacy plots within the park. The expanded inset shows the four Rock Creek legacy plots, RR1, RR2, RF1 and RF2, in relation one another, to the Rock Creek trail (curved red line), to Rock Creek (blue line) and to the park road (red and white line).

Rock Creek Legacy Plots

The long-term survey area occurs on four, ~.08 ha Rock Creek legacy plots located at 63°43'46.94"N 148°58'41.68"W (Figure 1, Rexstad *et al.* 2005). Rock Creek intersects mile three of the park road. The four plots are located along Rock Creek (elevation 2400 ft.) and are approximately 1.5 km north of the park road. The plots are accessed via a 30-minute hike along the Rock Creek park trail and moose trails that traverse the eastern ridge above Rock Creek. Two of the plots, (RR1 and RR2) are in riparian habitat and the other two (RF1 and RF2) are on the forested west ridge overlooking Rock Creek. The plots are named such that the first letter represents the watershed (i.e. “R” is for Rock Creek) and the second letter represents the habitat type of the plot (i.e. “R” for riparian and “F” for forested”). Habitat on the plots represents a typical boreal forest with a mix of dwarf birch and willow, wild grasses, sphagnum, and various berries with mixed black, white, aspen and poplar forest stands. A map of the four Rock Creek plots is shown in Figure 1.

Sampling Methods

Trapping methods follow those outlined in the protocol developed during the LTEM pilot work (Rexstad *et al.* 2005) and the CAKN monitoring program (Schmidt *et al.* 2017). Each of the four Rock Creek plots is a 100m x 100m square grid, approximately 0.8ha in area, containing 100 Sherman live-traps that are placed 10m apart. All trap locations are permanently marked with subtle metal tags denoting the name of each trapping plot and trap location identification (e.g. plot RR1, trap 1B) so traps can be placed within 1m of the same location each year. During the trapping week, flagging marks each trap location so traps can be quickly located and accurately identified. The temporary flags are labeled with the exact trap location to mitigate errors in trap identification. Further, because trap line trails are also used by moose and are circuitous to move around vegetation, entire trap lines of 10 traps (e.g. line 1, traps A-J; line 2, traps A-J; line 3, traps A-J) are labeled alternately with either blue or pink flagging so field technicians can easily follow and stay on the correct trap line. Flagging in this way prevents accidental sampling of traps on adjacent lines. Pink and blue flagging are used because foliage begins to change color in DENA in August and other colors, such as orange, yellow, green and red become difficult to distinguish from vegetation. Flagging is removed after the survey week but the metal tags remain to re-establish trapping plots in subsequent years.

We conduct field work for one week, including travel to and from DENA, training, camp and plot set up, sampling, and camp and plot break down. The crew camps on site for the week to increase sampling efficiency and mitigate trapping mortalities. The survey week begins on a Monday and concludes on a Sunday, with sampling days occurring Tuesday evening through Saturday evening (Table 2). All camping and scientific equipment is backpacked into the plots on Monday. 400 Sherman live traps are deployed on the four Rock Creek Legacy plots (Furtsch 1995; Rexstad *et al.* 2005; Schmidt *et al.* 2017) on Tuesday. Traps are baited with irradiated sunflower seeds (microwaved to prevent germination) and biodegradable cotton bedding (nestlets). Biodegradable bedding that will degrade, such as cotton nestlets and down feathers, is preferable to synthetic, particularly if bedding is stolen by birds and squirrels. Further, synthetic bedding, such as batting used in pillows, may pose a choking hazard for the animals when they shred it by mouth to make a

nest. Traps are covered with plastic trap covers to protect them from the rain and sun and are checked 3 times per day (0600hrs, 1300hrs and 2000hrs) to minimize morbidity and mortality and enhance population estimates. By the end of the four-day sampling period, 4800 trap checks have been conducted (400 traps x 3 checks x 4 days).

Table 2. Weekly sampling schedule for Small Mammal monitoring in DENA.

Mon	Tues	Wed	Thur	Fri	Sat	Sun
Drive to DENA	Training	Trap check 0600	Trap check 0600	Trap check 0600	Trap check 0600	Pull traps
Training	Set up plots x2	Trap check 1300	Trap check 1300	Trap check 1300	Trap check 1300	Break camp
Haul gear (2-3 trips)	Set traps x4 plots	Trap check 2000	Trap check 2000	Trap check 2000	Trap check 2000	Haul gear (2-3 trips)
Set up camp	Open traps 2000	–	–	–	Close and pull traps	–
Set up plots x2	–	–	–	–	–	Drive to FAI

Small mammal populations, including three target species of voles (northern red-backed vole, *Myodes* [formerly *Clethrionomys*] *rutilus*; tundra vole, *Microtus oeconomus*; and singing vole, *Microtus miurus*) are sampled using mark-recapture methods via live-trapping techniques. Non-target species, such as shrews (*Sorex sp.*), weasels and squirrels are identified to genus or species and released. When animals are captured, individuals are scanned for a tag, identified by sex and species, weighed and checked for parasites and reproductive status. Unmarked target individuals, are implanted subcutaneously near the shoulder blades with passive integrated transponder (PIT) tags (about the size of a grain of rice). Once implanted, animals are scanned for their unique, 10 to 15-character, alpha-numeric identification code and released. Data are error-checked in the field and PIT tag codes are verified against an inventory list to prevent typographical errors and ensure data integrity.

Small Mammal Mortalities and Museum Voucher Specimens

Despite many precautions to prevent mortalities during the live trapping in DENA, some deaths occur, usually as a result of hyper- or hypothermia. Dead animals are placed in individual plastic bags immediately after removal from traps along with a data card identifying species, sex, weight, date, time, trap location, plot, latitude, longitude and observer's initials. Carcasses (or mortalities) are stored in plastic containers in bear barrels and stored in a cool place until they can be transported to the specimen freezer in Denali's resources building (usually within hours of collection). Mortalities are loaned to the University of Alaska Museum of the North Department of Mammalogy (UAM), where they are processed into museum-quality voucher specimens and archived. The NPS loans mortality specimens to the UAM for preservation, education and comparative studies. This cooperation allows the specimens to be numbered and cross-referenced in both the UAM's database

(ARCTOS) and the NPS Museum Database (ICMS). Archiving specimens in partnership with UAM allows the long-term, DENA Small Mammal collection to be accessible to the public and other researchers for study. Further, UAM may provide confirmation of small mammal specimens' species identification and sex using analyses of dentition and genetics to assess the biodiversity of small mammal species occurring at Rock Creek in DENA.

Monitoring Schedule

The Central Alaska Network Small Mammal monitoring has occurred annually from 1992-2017. All four of the Rock Creek plots are scheduled to be sampled annually and in perpetuity. Since 2005, the survey has targeted the week of August 12 so monitoring occurs approximately at the same time each fall. This is the time of year when annual densities are expected to be highest after a summer's worth of reproduction but before inclement winter weather diminishes the population.

Data Management

Data management for the Small Mammal monitoring program will proceed through an ongoing life cycle as shown in Figure 2. (NPS 2008a). Major stages of the life cycle include data collection, data entry and import, quality control, data product documentation and archival, seasonal closeout, dataset certification, and data analysis and reporting (NPS 2008b).

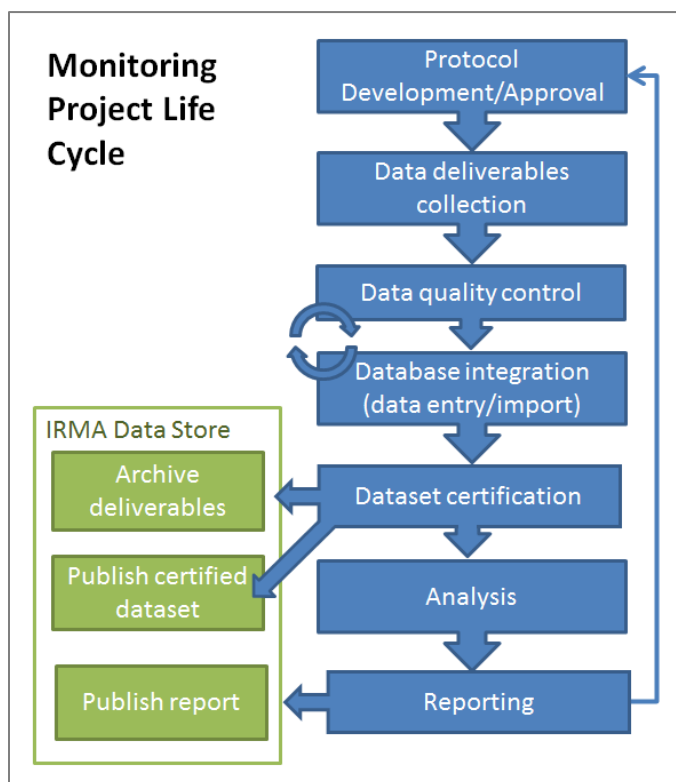


Figure 2. Long-term monitoring project data management life cycle.

An overview of each component of the Small Mammal monitoring data management life cycle follows. Specific procedures given in standard operating procedures.

NPS Standards

Data Quality

Director's Order #11B (NPS 2005b) mandates a high level of information quality from the service's scientific programs:

The National Park Service will ensure that information it releases will be developed from reliable data sources and will otherwise ensure information quality at each stage of information development. The NPS's methods for producing quality information will be made transparent, to the maximum extent practicable, through accurate documentation, use of appropriate internal and external review procedures, consultation with experts and users, and verification of the quality of the information disseminated to the public. The NPS will also keep users informed about corrections and revisions.

Information will be developed only from reliable data sources based on accepted practices and policies utilizing accepted methods for information collection and verification. It will be reproducible to the extent possible. Influential information will be produced with a high degree of transparency about data and methods. The information should include all pertinent information to allow the public to understand the park's legislative authorities, mission, activities, organization, strategic plan, performance plan, and performance accomplishments.

Director's Order #11A section 5.8: Data Integrity Standards (NPS 2005a) outlines the NPS policy for accuracy, completeness and review:

All information owners will maintain all official NPS records and data in a manner which meets the highest data integrity standards, including timeliness, accuracy and completeness (also see DO #11D). Each information owner will take whatever steps necessary to ensure that NPS systems have sufficient data quality reviews and audits from both an internal system perspective, as well as externally thorough control reviews.

Adherence to the data management procedures in this monitoring protocol will ensure compliance with Director's Order 11 (DO#11).

Freedom of Information Act

The Network will comply with all FOIA restrictions regarding the release of data and information as instructed in NPS Director's Order #66B (NPS 2005c).

Records Management

Direction for managing physical and digital materials is provided in NPS Director's Order 11D (NPS 2012).

The NPS has a strong business need for excellent records management, in that the Service's mission is to care for natural and cultural resources so that they are left 'unimpaired' for future generations. This requirement for managing resources in perpetuity sets a high standard for record keeping. No resources can be managed well in

the future without complete records of how they were managed in the past. Because the NPS manages some of America's most significant cultural and natural resources, the public also has a significant interest in our records. Section 1.9.2 of NPS Management Policies 2006 (NPS 2006) states that the future of the Service depends on the availability, management, dissemination, and preservation of information, and directs the agency to implement professional quality programs to manage information resources.

Core Functional Model

Data generated by the CAKN Small Mammal monitoring program are managed according to the Core Functional Model described in Figure 3.

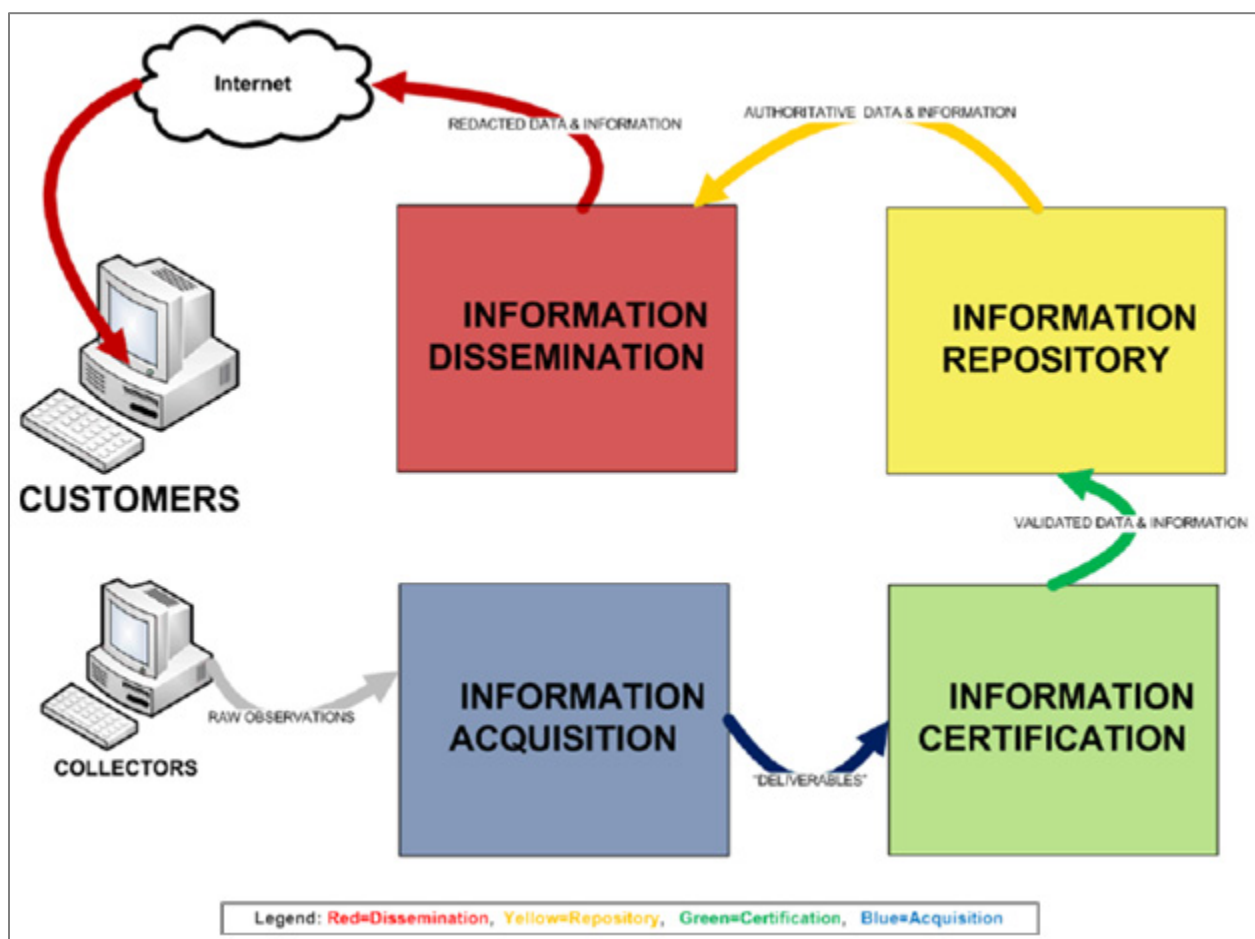


Figure 3. The CAKN Core Functional Model overview.

Dissemination services (red, Figure 3) provide all deliverables to all customers using internet web sites and web services through the NPS Integrated Resource Management Applications (IRMA) Data Store. Repositories (yellow) store the certified inventory and monitoring products called for in the protocols. Certification processes (green) assure repositories have the highest quality data and that sensitive items are restricted to authorized users. Data acquisition processes (blue) led by park staff

and cooperators include a wide array of tasks, ranging from collecting raw data to composing reports on long-term trends.

Data Sensitivity Statement

Network staff must ensure that all references to protected information are removed or obscured in any reports, publications, maps, or other public forum. Following the standard for Freedom of Information Act (FOIA) requests, the Network will segregate the non-releasable information and where practical will not withhold associated releasable information. Metadata for that dataset and the IRMA citation must also be updated to reflect that the associated data is sensitive. Network staff must ensure that all references to protected information are removed or obscured in any reports, publications, maps, or other public forum.

The project leader is responsible for maintaining the security of data released to any NPS dataset catalog and ensuring confidentiality agreements are in place before sharing data with any non-NPS entity.

Roles and Responsibilities

Project Leader

- Ensures that the Small Mammal monitoring protocol and all of its standard operating procedures are current and up to date. If methods must be changed the project leader ensures that the standard operating procedures remain in sync with actual data management operations. Ensures data are collected, processed and integrated with the master database consistently and strictly according to the specifications and methods described in the standard operating procedures. Performs an annual closeout with the Network program manager and data manager.
- Certifies the Small Mammal monitoring dataset for analysis and publication and assures that the Small Mammal monitoring standard operating procedures (SOPs) are current and up to date.
- Performs analytical procedures and reports on findings
- Arranges technicians and budgets for data management costs, such as data entry and processing.

Data Manager

- Provides for the security, longevity and accessibility of the Small Mammal monitoring dataset.
- Maintains software and hardware for file backups and security, databases, custom and proprietary applications and GIS tools.
- Guides personnel in data processing techniques, metadata generation and product archival in NPS data stores and enterprise databases.
- The data manager is not responsible for data entry, processing, metadata generation or archiving data deliverables.

Quality Assurance

The Small Mammal Vital Sign plans for high data quality assurance by proactively deploying a system of administrative procedures and technological safeguards including:

- Standard operating procedures designed to minimize the introduction of errors during data collection and processing.
- Field crew training.
- Standard database security and integrity functions and data integrity constraints (Frakes *et al.* 2015) to enforce compliance with the Vital Sign's logical data model.
- Application level data entry checks and business rule enforcement.
- Periodic data quality audits and reports.

Data Collection

Data Collection Overview

The Small Mammal monitoring program creates and maintains specific data deliverables (Table 3). Raw data deliverable files are collected during surveys and processed for quality (Figure 4).

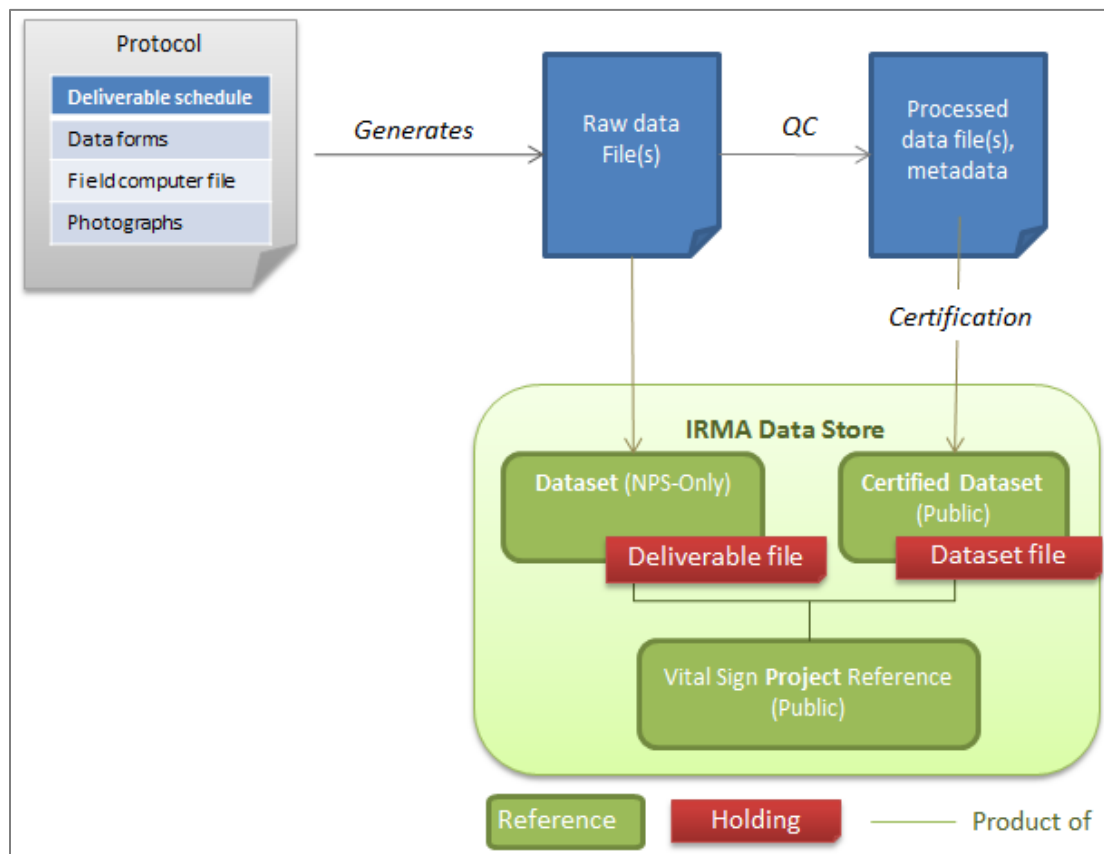


Figure 4. Data products processing and flow diagram. Data deliverables are collected on a cycle, processed to analytical quality, certified, and published to the IRMA Data Store. Raw deliverables are retained in private Dataset references.

Table 3. Small Mammal monitoring data deliverables schedule. *PI = Principal Investigator

Identifier	Deliverable	Format	Schedule	Responsibility	Description
SM01	Small mammal survey databases: .xlsx (by year) and .accdb (all years)	Tabular	Remeasuremen t + 1 year	PI*	Tabular Access database containing processed QA/QC-checked survey data, including small mammal capture and location data. Data are verified and validated in an annual Excel file. The Access database contains processed QA/QC checked survey data, including attributes of each capture record. Proofed data are appended to this database each year.
SM02	Small mammal survey Park Observer iPad application files	.poz,.csv files	Remeasuremen t + 1 year	PI	Folder containing iPad Park Observer .poz and raw.csv files with, field-collected survey data prior to importing and processing those data in the in Excel and Access.
SM03	Small mammal survey digital images (photographs)	.jpg	Remeasuremen t + 1 year	PI	Digital images of small mammal survey field work
SM04	Small mammal survey data collection field data notebook and field notes	Physical forms and and .pdf scans	Remeasuremen t + 1 year	PI	Annotated annual field data notebooks and field notes generated during small mammal survey

In the field, we use Rite-in-the-Rain data notebooks and portable iPads with a specialized NPS enterprise application, Park Observer, for data collection. The Park Observer app has a background map of the Rock Creek study area and four legacy plots (.tkp) and data forms (.obsprots) into which we enter data. After each trap check, the data from each of the iPads is backed up in the field by emailing it (to 'yugaipads2016@gmail.com'). Data in the field notebooks is backed up after each trap check by using the iPads to take photos of the records from each trapping session. In the office after the field work is completed, the data from the iPads (.poz files) are downloaded to iTunes or emailed and are organized into folders by date, plot, trapping session (time of day) and observer initials (e.g. Aug122017_RR1_1pm_MJF; Note: do not use '/' in files names for Park Observer or files are not exportable). All data collected are copied and saved to a backup drive and re-imported to the project's geodatabase (Smammals.gdb) containing annual data and all trap locations for the four plots. The geodatabase therefore contains spatial data (animal captures and trap locations) relevant to the survey and these data can be verified against the hardcopy data in the data notebooks and edited as needed using ArcGIS (ESRI, Redlands, CA). We also use an existing Access database (e.g. small_mammals_year.mdb) containing all previous years' small mammal data for proofing and certifying data. All data notebooks and field notes are scanned and archived to the CAKN drive (J:\Monitoring\Small_Mammals\Scanned Field Notebooks and Databooks\2017Scanned Field Data).

Field deliverables will be processed for quality and incorporated into a file based data management system on IRMA at this Small Mammal Master IRMA Project reference:

<https://irma.nps.gov/DataStore/Reference/Profile/2219630>.

A previous data base, was built at INPYUGAMS08SQL\NUNA, but currently is used only for archival purposes. In addition, Ed Debevec, an early primary investigator for the project, built a Microsoft Access database for the initial years of the survey that contains data and metadata from 1992-2000 (smdata02FromEdDebevec.mdb stored at J:\Monitoring\Small_Mammals\Data). This older database is built on a two-tiered model consisting of a single client-server back-end database named 'CAKN_SmallMammals' (Microsoft SQL Server 2008R2) serving multiple front end analytical and data management applications (e.g., Microsoft Access, ArcGIS, R). The CAKN_SmallMammals database is situated behind the NPS firewall and access is limited to NPS staff until data are proofed and of the quality required to be released to the public on IRMA. Database access, security and administration will be managed by the Network data managers. The local Small Mammal monitoring database will be the working database used for assessing and improving data quality until such time that it is certified. At that time a certified copy will be attached to the I&M database server in Denver, CO and the dataset's reference in IRMA updated with metadata and access information.

Deliverables Schedule

The Small Mammal monitoring program creates and maintains specific data deliverables for customers. Each deliverable is disseminated directly from the IRMA Data Store, the single authoritative source for Network products. In the event that a data product ever diverges from that in the IRMA Data Store the latter version should be considered authoritative.

The Small Mammal monitoring program will create and maintain the deliverables or data products shown in Table 3.

Data Entry/Import

Field data collection involves surveys to collect the majority of the products in the deliverables schedule above. The following is a brief summary of the data downloading, verification and editing processes; details can be found in SOP 8 (Data Downloading and Backup), SOP 9 (Data QA/QC and Formatting), and SOP 10 (Data Analysis) and in Schmidt *et al.* 2017.

Most data processing will occur after returning from the field because crews are camping for the duration of the field work. However, data backups of iPads and field data notebooks will occur in the field after each trap check (observers will back up their iPad Park Observer data after each trap by emailing the data to “yugaipads2016@gmail.com” and will back up their data notebook records by taking photos of them with the iPads). Once back from the field, observers will download their iPad Park Observer data into a Microsoft Excel and Access database housed on the CAKN network drive. Data will be verified and reconciled against small mammal field data notebooks, field notes and photographs. Any changes to the field data notebooks will be crossed out with a line and initialed and the new information written below. Data will be validated through various filtering and sorting. Data entry proofing will be conducted by a person different from the one who entered the data. Data discrepancies between field data notebooks, field notes, photographs and Park Observer data will be reconciled or excluded from analysis (SOP 8) in consultation with the project manager. After the QA/QC process is completed, data are uploaded and appended to the multi-year Access database where they are spot checked by the project manager and an additional technician prior to archiving and analysis.

The project manager will assemble all data following the surveys and perform a final QA/QC (SOP 8 and 9). They will check all original data notebooks for legibility and completeness, or will delegate this to a technician who was not involved with the data entry. Any remaining discrepancies between the data notebooks and the iPad Park Observer data will be discussed and corrected with the observer. Questionable entries are highlighted and discussed with data collectors and the program manager to reconcile discrepancies, when possible. The field data notebooks and field notes will be scanned and saved into an annual .pdf following the final QA/QC, and the original Park Observer files (.poz and .csv) and photographs will be labeled and processed with standardized metadata for incorporation into the IRMA file management system (see [Product Archival, Seasonal Closeout and Dataset Certification Procedures for the Arctic and Central Alaska Inventory and Monitoring Networks](#); ARCN/CAKN Data Management Standard Operating Procedure #1 (Miller 2017). All digital files should be transferred to the appropriate ARCN/CAKN network drives for permanent storage (SOP 8).

All small mammal data within the Excel file are processed and edited as needed before analysis using the Access database and R. The project manager will verify the Excel data with the hardcopy data (field data notebooks and field notes, data from Park Observer and photographs and edit the file as needed. The Access database is then queried and data are extracted into the file format used in R to

run the models to generate estimates of small mammal abundance and density using spatially-explicit capture-recapture models fit in a Bayesian hierarchical framework (Schmidt *et al.* 2017). Refer to SOPs 8 and 9 for additional details about the data QA/QC, database editing and formatting that are required for incorporation into the IRMA Data Store (Miller 2017).

Small Mammal monitoring data is stored in a master IRMA Data Store file base management system at: <https://irma.nps.gov/DataStore/Reference/Profile/2219630>.

Quality Control

Ensuring high data quality is a high priority for the Small Mammal Vital Sign. Quality control procedures focus on verifying data as well as identifying and correcting errors in final data products. Quality control safeguards include:

- Data verification and/or double data entry procedures
- Spot checking
- Automated programmatic range, domain or impossible value checking
- Graphical and visual exploratory data analysis
- Statistical error or outlier identification
- Data quality audits and reporting.
- Dataset certification

Product Archival and Documentation

Director's Order 11D states that all records of natural and cultural resources and their management are considered mission-critical records (necessary for fulfillment of the NPS mission) and must be permanently archived. Mission critical deliverables are considered to be archived when they are uploaded to the IRMA Data Store. With few exceptions IRMA is the only authoritative repository for mission critical I&M products.

Data archiving is done in concert with seasonal close out and data certification (ARCN/CAKN DMSOP-1, Miller 2017). All data are archived in the following ways:

- IRMA Data Store. Formats may include:
 - Raw and processed data files described in this protocol's deliverables schedule.
 - Human readable text file of all Small Mammal monitoring databases. A SQL script is built that can recreate the entire database and all the data within it.
 - Network file server

Small Mammal monitoring program data are maintained in file based management system at the master IRMA Data Store: <https://irma.nps.gov/App/Reference/Profile/2219630>.

Small Mammal monitoring program data are maintained on a network file share in the Fairbanks Administrative Center (FAC) in Fairbanks, Alaska. The certified database content is backed up to backed up to off-site storage at the NPS Natural Resource Stewardship and Science Directorate (NRSS) in Denver, Colorado and a separate NPS facility in Fairbanks. The NRSS and FAC use

enterprise-level business continuity processes to maintain data security. In the event of catastrophe at one site, the original data may be restored from the other.

IRMA Data Store

The NPS IRMA Data Store is the primary organizational repository and publication platform for information related to the Small Mammal monitoring program. The Small Mammal Vital Sign has a single master IRMA project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219630>) to which all products are related (Figure 5).

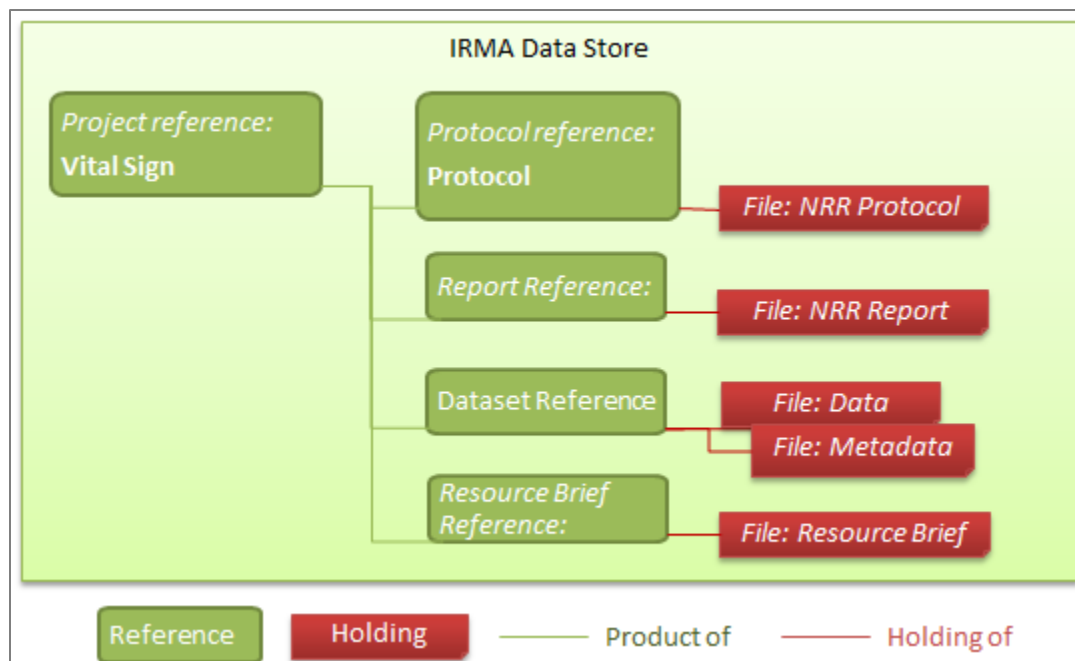


Figure 5. Standard ARC/CAKN Vital Sign Project reference architecture in the IRMA Data Store.

The public Vital Sign web page covering Small Mammal monitoring will publish the releasable contents of this reference and its related references via web services. It is the joint responsibility of the PI and the data manager to keep the system of related IRMA Data Store references up to date.

Reports

Reports will be published in the NPS Natural Resource Report publication series (<http://nature.nps.gov/publications/nrpm/index.cfm>) or professional journals. Reports and journal articles reporting analytical results will be published in tandem with the dataset that was used.

Natural Resource Reports are automatically tracked and announced to Network program managers and data managers but journal articles are not. The PI will create Data Store references for journal articles related to monitoring, link them to the Vital Sign's IRMA Project reference (Figure 5) and notify Network staff of their presence.

Certified Dataset

All reports providing statistical results will publish the data on which they were based. Metadata will be provided as well as a link to the certified original dataset (DO 11A, NPS 2005a). Data are made available through IRMA in machine readable formats according to Director's Order #11A (NPS 2005a) and as mandated by the Federal Open Data Initiative (Executive Order No. 13642).

The Small Mammal Vital Sign will have a single public dataset reference in the IRMA Data Store to which certified data will be published (Figure 5). This reference will be the only authoritative data source available to the public: (<https://irma.nps.gov/DataStore/Reference/Profile/2219630>).

Resource Brief

The I&M resource brief is the primary outreach document for the Small Mammal monitoring program. The principal investigator will revise any existing resource brief after new findings to reflect current understanding of the resource's trend and implications for park management. Resource briefs are made available on the Network web site through an IRMA Data Store Resource Brief product reference that is attached as a product of the main Vital Sign Project reference (Figure 5).

Products Publication

Reports, datasets and other monitoring products are published through NPS websites using the Vital Sign's master Data Store Project reference via web services exposed by the IRMA Data Store. Authoritative products will only be distributed through the IRMA Data Store (Figure 5).

Metadata

All project datasets, including spatial and non-spatial data, are archived in the IRMA data store with metadata (DO 11A, NPS 2005a; Figure 5). The mandate for adequate metadata comes from Director's Order #11A (NPS 2005a):

All NPS data systems will develop data dictionaries and conform to available NPS organization-wide dictionaries. Geographic Information and Metadata must meet all Federal standards, DOI standards and NPS standards.

Preferred metadata formats include [Federal Geographic Data Committee](#) (FGDC 1998) and [Ecological Metadata Language](#) (KNB 2017).

Line of Sight

Line of Sight is the informal name given to the I&M program's philosophy that every datum should be inextricably linked in a traversable way to the standard operating procedure and protocol version that guided its collection (Figure 7). This custodial chain is maintained through metadata columns in the main monitoring database coupled with metadata maintained in each protocol and standard operating procedures' IRMA reference. A data consumer will be reliably able to access a data record and discover the standard operating procedure version that defined its collection and processing.

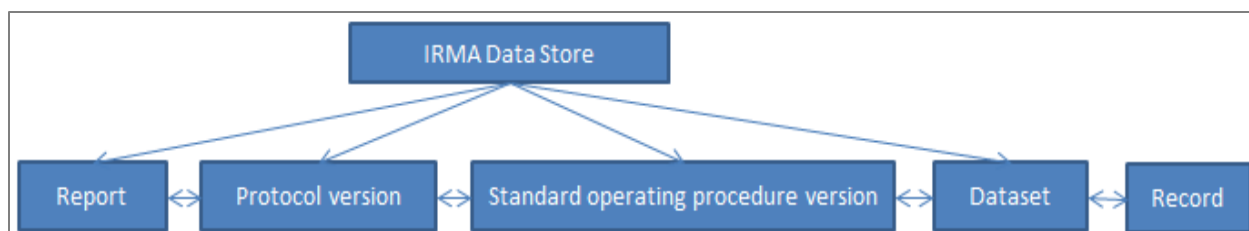


Figure 6. Each informational component informs and is informed by other components. Discovery of one component leads to discovery of all other components in a formalized data management chain of custody

Data and Information Security

Digital products produced by the Small Mammal monitoring program will be stored in the IRMA Data Store in a file based management system, databases on I&M and/or local servers, and the Network file server in descending order of preference. Under no circumstances will any mission-critical information reside on individual I&M staff computers whether they are assigned to monitoring personnel by the NPS or not. Project materials will be secured and available on I&M servers at all times. The data manager, in conjunction with IT staff at FAC and with the Network support office in Ft. Collins, CO is responsible for backups, security and longevity of monitoring data.

Closeout

Closeout is the part of the Small Mammal monitoring data management life cycle through which seasonal data collection files (data deliverables, Table 3 and Appendix A) are archived in the IRMA Data Store (Figures 4 and 5). The Small Mammal monitoring program will follow the procedures described in [‘Product Archival, Seasonal Closeout and Dataset Certification Procedures for the Arctic and Central Alaska Inventory and Monitoring Networks: ARC/CAKN Data Management Standard Operating Procedure #1’](#) (Miller 2017).

Closeout happens after a re-measurement cycle when data files have been collected, processed and certified. Deliverables and the certified dataset are archived as holdings of private and public Dataset References in Data Store (Figure 5 and Figure 43; Miller 2017). Closeout is complete when seasonal Dataset holdings reconcile with the deliverables schedule (Figure 7).

After closeout all permissions are removed from references except for the project leader and data manager. The references are then linked to the main Small Mammal monitoring IRMA Project reference so that it becomes discoverable.

The closeout method described above will ensure that all data objects collected during a re-measurement cycle are accounted for, documented and available for perpetuity should the need arise to re-use or revisit the data.

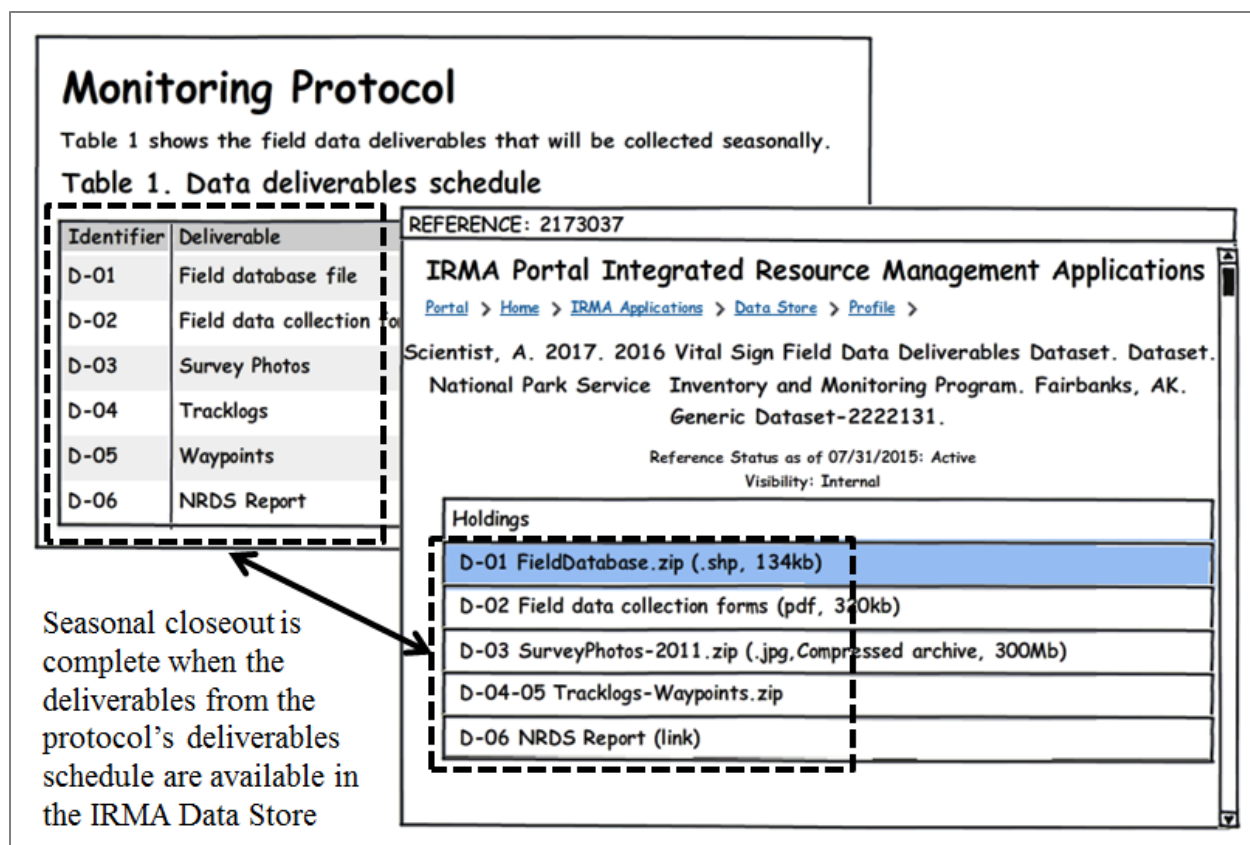


Figure 7. Data deliverables are defined in the monitoring protocol and archived in IRMA Dataset references after each re-measurement cycle. Closeout is complete when the holdings in the re-measurement Dataset reference match the deliverables in the protocol's data deliverables schedule.

Certification

Certification is the phase of the Small Mammal monitoring data management life cycle where the principal investigator formally confirms that the Vital Sign's dataset is ready for analysis (NPS 2016). Certification also affirms the scientific, administrative and technical integrity of the program including:

- The protocol and standard operating procedures are current. All technical changes are up to date and documented.
- Raw and intermediate data deliverables have been processed via quality control procedures, have been integrated with the vital sign's database or data management system and have been archived and documented appropriately for posterity.
- Each data record is traceable to the protocol version and SOP version that guided its collection.
- All closeout activities have been performed.
- The certified database or data files have been published to the Vital Sign's public Dataset reference in the IRMA Data Store.

- The Vital Sign's IRMA Data Store references and cross-links are complete.
- The dataset is of sufficient quality that analyses may be performed on it and the results

Certification will follow the procedures described in Miller (2017).

Analysis and Reporting

Analysis

Data analysis procedures are described in detail in SOP 10, the Small Mammal Data Quality Standards and Schmidt *et al.* 2017. The mark-recapture data generated from live-trapping of the three target species from one session in mid-August annually (1992-2017) were used to estimate vole abundance, density and assess the amplitude of population cycles (see Schmidt *et al.* 2017). Spatially-explicit capture-recapture models (Royle and Dorazio 2008; Efford *et al.* 2009; Borchers 2012; Efford and Fewster 2013) fit in a Bayesian hierarchical framework (e.g., Royle and Young 2008; Gardner *et al.* 2009, 2010; Royle *et al.* 2009) were employed.

Reporting

Written reports will consist of: 1) survey summary reports, 2) administrative reports, 3) resource briefs, and 4) peer-reviewed articles in scientific journals or the NPS Natural Resources Technical Report series (NRTR). These reports may be written by the program manager and/or CAKN and park unit staff. Oral reporting may consist of presentations to the CAKN technical committee, subsistence committees, and presentations at scientific conferences. Detailed interpretation of estimates, including trend estimates, will occur at longer time intervals (e.g., after 3-4 surveys), and will be published as peer-reviewed articles or as NRTR reports. The target audience for these more comprehensive publications will be the scientific community. Such publications will document long-term trends or further methodological advances and will include maps, graphs, figures, and other visuals to facilitate comprehension of findings. All products will be made available on the IRMA Data Store (<https://irma.nps.gov/DataStore/Reference/Profile/2219630>).

Budget

The estimated annual cost (based on FY2016 dollars) of implementation of the Small Mammal Monitoring Protocol is presented in Table 4. The CAKN may have sampling performed by non-NPS personnel due to limited staff or availability and may have to increase costs to use partners (e.g. USFWS staff, volunteers, Student Conservation Association interns) when developing those contracts and agreements. Parks may provide support for monitoring, including staff participation in sampling, funding, logistical support and housing. This budget does not include support provided by parks or other partners, other than indicated savings on using GOVs for transportation, camping on site for the duration and using Volunteers In Parks (VIPs) for assistance in the field.

The YUGA Biologist (PI) provides project oversight. Field surveys are performed by one GS-11 permanent YUGA Biologist, two YUGA GS-04/05 biological technicians, and 3-9 other youth interns including Volunteers in Parks (VIP), Student Conservation Association (SCA), Youth Conservation Corps (YCC) or students and/or partners from other agencies or organizations. The CAKN Biometrician formats and analyzes the data after certification by the PI. Surveys occur annually for a week, targeting August 12. Data analysis and reporting take place each spring. A total of 4800 trap nights are conducted annually (3 trapping sessions/day x 4 days x 400 traps). This

requires approximately 60-84 hours of field time per survey crew member for the week. The following budget is for one (1) sampling year = 7 field-days and 4800 trap nights for the crew. This budget has been shown to be sufficient to conduct field work, collect data, proof, certify and archive data, and analyze and report on results

Table 4. Estimated annual operating cost (based on FY2017 dollars) for implementation of the CAKN Small Mammal Monitoring Protocol.

Category	Item	Costs (FY 2017)	Notes
Personnel	YUGA Biologist	\$1,000	0.07 FTE GS-11-base salary in kind
	CAKN Biometrician	\$1,000	0.06 FTE GS-12- base salary in kind
	2x YUGA Biology technician	\$2,000	0.21 FTE GS-05- base salary in kind
	2x YUGA SCA Interns	\$1,500	0.21 FTE GS-05 equivalent-salary in kind
	3-7x VIPs	\$0	0.21 FTE GS-03-05 equivalent-salary in kind
	Total Personnel Costs (annual)	\$5,500	(in kind)
Equipment Supplies	Field Supplies	\$2,500	New PIT tags, reader maintenance
	Total Equipment Costs (annual)	\$2,500	–
Travel	Transportation and Lodging	\$0	Travel in GOVs, camp for duration
	Backcountry per diem	\$2,100	7 days x 12 people
	Total Travel Costs (annual)	\$2,100	–
Total Annual Costs		\$10,100	Estimated total implementation cost for each field-year (includes in kind)

Safety

Implementation of this protocol has multiple complex risks. Staff will continuously evaluate all risks at the programmatic, personnel, and site level. Programmatic-level safety information is presented here and procedures to mitigate risks associated with specific activities related to protocol implementation (such as safe operations of vehicles, injury reporting and accident reporting) are addressed in standard operating procedures below.

Job Hazard Analyses (JHAs) were completed for all personnel who implement portions of the protocol in which risks and risk abatement strategies (including training needs) were identified. Risks and abatement strategies for all staff were synthesized to develop a protocol-level JHA. The protocol JHA was then used to perform a programmatic-level Green-Amber-Red (GAR) risk analysis to assess whether implementation of this protocol could be accomplished within an acceptable level of risk.

Specific safety concerns include:

- Crew members will spend many hours (and miles) hiking and camping in remote areas over rugged terrain while sampling.
- Crew members may be working long hours.
- Crew members will frequently be exposed to inclement weather and will be working for extended periods of time in remote areas with potentially rapidly-changing weather conditions.
- Crew members will be exposed to hazardous wildlife (bears, moose, etc.).

Based on the JHA and associated risk abatement measures it was determined that this protocol can be safely implemented provided that CAKN and partner staff implement it in accordance with the referenced SOPs and recommended risk abatement strategies. In addition to SOPs that have been developed to safely implement this protocol, specific training needs for all staff have been identified including certification in basic and wilderness first aid, bear safety and remote communications. To increase the overall level of safety and awareness, obtaining additional levels of training beyond basic certifications will be encouraged.

Safety procedures will be routinely reviewed with Network staff and partners before field operations as prescribed in SOPs. Personnel-level JHAs for staff will be reviewed and revised annually as a part of the performance review cycle. Safety SOPs are reviewed at least annually and updated as necessary to ensure that they adequately mitigate risks to personnel, property, and the public.

In addition to protocol-specific safety procedures and guidelines, CAKN and partner staff will follow the general guidelines set forth in the NPS Occupational Safety and Health Program (Directors Order #50B, September 2008).

Standard Operating Procedures

To ensure consistent implementation of this protocol over time, the following Standard Operating Procedures (SOPs) have been adopted from ARCN Sheep and Yellow-billed Loon SOPs, LTEM SOP (Rexstad *et al.* 2005) methods or developed as needed for CAKN Small Mammal monitoring (Table 5). To the greatest extent possible, SOPs are adopted from procedures approved and implemented programmatically through other monitoring efforts. All approved SOPs will be published in the NPS Natural Resource Report series and the latest approved versions of operational SOPs are always available for download at the NPS Integrated Resource Management Applications portal at <http://irma.nps.gov>. The SOPs will exist as separate stand-alone documents on the master IRMA data store in a file data management system:

(<https://irma.nps.gov/DataStore/Reference/Profile/2219630>).

Table 5. Standard Operating Procedures required to implement the Small Mammal Monitoring Protocol in CAKN (DENA). Table lists SOPs by task category.

Subject	SOP	Citation	Notes	Link to Published Document / IRMA record
Preparations for the Field Season	1	Flamme, M. J. 2018. Standard Operating Procedure (SOP) 1: Preparations for Field Season. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Modified from ARCN Sheep: Rattenbury, K. L., and J. H. Schmidt. 2017. Standard Operating Procedure (SOP) 1: Preparations for the Field Season, Version 1.0. Protocol for Monitoring Dall's Sheep, Arctic (ARCN) and Central Alaska (CAKN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska. https://irma.nps.gov/DataStore/Reference/Profile/2238902 ; Rexstad <i>et al.</i> 2005.	https://irma.nps.gov/DataStore/Reference/Profile/2219630
Field Notebook and iPad Setup for Field Data Collection	2	Flamme, M. J., S. C. Swanson, D. T. Shertz and J. B. Hughey. 2018. Standard Operating Procedure (SOP) 2: Field Notebook and iPad Set up for Field Data Collection. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Modified from http://akrgis.nps.gov/observer/no-wifi.htm and ARCN Loons: Flamme, M.J., D. T. Schertz, and K. L. Rattenbury 2017. Standard Operating Procedure (SOP) 2: Field iPad Set up, Version 1.0. Protocol for Monitoring Yellow-billed Loons in Arctic (ARCN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska. Available online at https://irma.nps.gov/DataStore/Reference/Profile/2216938 ; Rexstad <i>et al.</i> 2005.	https://irma.nps.gov/DataStore/Reference/Profile/2219630

Table 5 (continued). Standard Operating Procedures required to implement the Small Mammal Monitoring Protocol in CAKN (DENA). Table lists SOPs by task category.

Subject	SOP	Citation	Notes	Link to Published Document / IRMA record
Training	3	Flamme, M. J., S.C. Swanson, P.D. Knavel. 2018. Standard Operating Procedure (SOP) 3: Training. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Modified from ARCN Sheep: Rattenbury, K. L. and J. H. Schmidt. 2017. Standard Operating Procedure (SOP) 5: Training Version 1.0. Protocol for Monitoring Dall's Sheep, Arctic (ARCN) and Central Alaska (CAKN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska. https://irma.nps.gov/DataStore/Reference/Profile/2214983	https://irma.nps.gov/DataStore/Reference/Profile/2219630
Plot and Trap Setup	4	Flamme, M. J. 2018. Standard Operating Procedure (SOP) 4: Plot and Trap Set up. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Rexstad <i>et al.</i> 2005; Schmidt <i>et al.</i> 2017.	https://irma.nps.gov/DataStore/Reference/Profile/2219630
Equipment and Tasks Lists	5	Flamme, M. J. 2018. Standard Operating Procedure (SOP) 5: Equipment and Tasks Lists. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Rexstad <i>et al.</i> 2005	https://irma.nps.gov/DataStore/Reference/Profile/2219630
Conducting Surveys	6	Flamme, M.J. 2018. Standard Operating Procedure (SOP) 6: Conducting Surveys. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Rexstad <i>et al.</i> 2005; Schmidt <i>et al.</i> 2017.	https://irma.nps.gov/DataStore/Reference/Profile/2219630

Table 5 (continued). Standard Operating Procedures required to implement the Small Mammal Monitoring Protocol in CAKN (DENA). Table lists SOPs by task category.

Subject	SOP	Citation	Notes	Link to Published Document / IRMA record
Data Collection in Notebooks and iPads	7	Flamme, M.J, and S.C. Swanson. 2018. Standard Operating Procedure (SOP) 7: Data Collection in Notebooks and iPads. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Modified from ARCN loons: Flamme, M. J., D. T. Schertz, K. L. Rattenbury and J. H. Schmidt. 2017. Standard Operating Procedure (SOP) 7: Data Collection, Version 1.0. Protocol for Monitoring Yellow-billed Loons in Arctic (ARCN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska. Available online at. https://irma.nps.gov/DataStore/Reference/Profile/2216938 ; Rexstad <i>et al.</i> 2005; Schmidt et al. 2017.	https://irma.nps.gov/DataStore/Reference/Profile/2219630
Data Downloading Proofing and Backup	8	Flamme, M. J., D. T. Schertz, S. C. Swanson and K.L. Rattenbury. 2018. Standard Operating Procedure (SOP) 8: Data Downloading, Proofing and Backup. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Modified from ARCN loons: Flamme, M. J., D. T. Schertz, K. L. Rattenbury. 2017. Standard Operating Procedure (SOP) 8: Data Downloading and Backup, Version 1.0. Protocol for Monitoring Yellow-billed Loons in Arctic (ARCN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska. Available online at https://irma.nps.gov/DataStore/Reference/Profile/2216938 ; Schmidt et al. 2017.	https://irma.nps.gov/DataStore/Reference/Profile/2219630

Table 5 (continued). Standard Operating Procedures required to implement the Small Mammal Monitoring Protocol in CAKN (DENA). Table lists SOPs by task category.

Subject	SOP	Citation	Notes	Link to Published Document / IRMA record
Data QA/QC Formatting and Archiving	9	Schertz, D. T., M. J. Flamme, K. L. Rattenbury and J. H. Schmidt. 2018. Standard Operating Procedure (SOP) 9: Data QA/QC, Formatting and Archiving. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Modified from ARCN loons: Schertz, D. T., M. J. Flamme, K. L. Rattenbury and J. H. Schmidt. 2017. Standard Operating Procedure (SOP) 9: Data QA/QC and Formatting, Version 1.0. Protocol for Monitoring Yellow-billed Loons in Arctic (ARCN) Inventory and Monitoring Networks. National Park Service, Fairbanks, Alaska. Available online at https://irma.nps.gov/DataStore/Reference/Profile/2216938 ; Schmidt et al. 2018.	https://irma.nps.gov/DataStore/Reference/Profile/2219630
Data Analysis	10	Schmidt, J. H., and M. J. Flamme 2018. Standard Operating Procedure (SOP) 10: Data Analysis. Protocol for Monitoring Small Mammals, Central Alaska (CAKN) Inventory and Monitoring Network. National Park Service, Fairbanks, Alaska.	Rexstad <i>et al.</i> 2005; Schmidt et al. 2017.	https://irma.nps.gov/DataStore/Reference/Profile/2219630

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Appendix A: Deliverables Schedule

Deliverable SM01: .xlsx (Microsoft Excel) and .accdb (Microsoft Access Database)

Deliverable SM01 includes a temporary annual Excel file and a permanent, multi-year Access database. The Excel file is a tabular database generated from Park Observer data files containing annual small mammal capture and location data. Data are explored, verified and validated against field data notebooks in the Excel file. Full processing and QA/QC instructions are in SOPs 8 and 9. The multi-year Access database contains all data fields collected for each capture record (See SOP 2). The Access database contains processed QA/QC checked survey data, including attributes of each capture record. Proofed and certified data are appended to the Access database each year for archiving and analysis. Microsoft Excel (.xlsx) and Microsoft Access (.accdb) format. Full processing instructions are in SOPs 8 and 9. Schedule: Re-measurement mid-August + 1 year. Responsibility: PI

Deliverable SM02: iPad Park Observer application survey files (.poz, .csv)

Deliverable SM02 includes the iPad application layers exported from Park Observer. Data are collected in Park Observer (small mammal capture information: species ID, location tag number, sex, etc., see SOP 2), in the field. Park Observer survey files are emailed to the PI during the survey. After the survey is completed, Park Observer files (“SmallMammalSurvey.poz” “Critter.csv,” “TrackLogs.csv,” and “GpsPoints.csv”) are downloaded and reimported to the Excel file for QA/QC, data verification, validation and are reconciled against field data notebooks. Full processing instructions are in SOPs 8 and 9. Schedule: Re-measurement + 1 year. Responsibility: PI.

Deliverable SM03: Survey digital images (photographs)

Deliverable SM03 includes digital images, videos and photographs of field work, habitat, scenery, wildlife, databooks, notes and screenshots of Park Observer files collected during the small mammal survey. JPEG format (jpg). Preferably georeferenced. Full processing instructions are in SOP 8. Schedule: Re-measurement + 1 year. Responsibility: PI.

Deliverable SM04: Survey data collection forms and notebooks

Deliverable SM04 includes scanned, annotated field data notebooks and field notes generated during the small mammal survey. Portable Document Format (.pdf). Physical files to be filed with PI and curated with regional curation. Full processing instructions are in SOP 2, 7, 8 and 9. Schedule: Re-measurement + 1 year. Responsibility: PI.

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.

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