



Moose Monitoring Protocol for the Arctic Inventory and Monitoring Network

Natural Resource Report NPS/ARCN/NRR—2018/1728



ON THE COVER

Moose congregating in the willows lining the Kobuk River during March.
NPS photograph by Kyle Joly.

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Executive Summary

This document describes the moose (*Alces alces*) monitoring protocol for the Arctic Inventory and Monitoring Network (ARCN) in Alaska. The network contains five units of the U.S. National Park Service: Gates of the Arctic National Park and Preserve (GAAR); Noatak National Preserve (NOAT); Cape Krusenstern National Monument (CAKR), Kobuk Valley National Park (KOVA) and Bering Land Bridge National Preserve (BELA). This protocol provides the monitoring methods and objectives for monitoring moose in this network. Specific instructions for implementing the monitoring methodology are found in the six Standard Operating Procedures (SOPs).

The ARCN has adopted a holistic view of network ecosystems and will track the major physical drivers of ecosystem change. Moose are considered good indicators of long-term habitat change within network ecosystems. Moose are crucial to many subsistence communities as a source of food that may be harvested on most National Park Service (NPS) land in Alaska, and are harvested by the general public on NPS Preserve lands. It is the responsibility of the NPS to monitor moose populations throughout the ARCN.

People travel from all over the world to visit national parks in Alaska to view and photograph wildlife, particularly the large mammals found in northwest Alaska. The non-consumptive value of wildlife is difficult to estimate, and it is the responsibility of the NPS to ensure opportunities like these remain unimpaired for future generations.

Various survey techniques have been used for estimating moose populations in the past. The stratified random sample design developed by Gasaway et al. (1986) and modified by ver Hoef (2001) was initially used in Alaska. Since its development in the late 1990s, the Geo-Spatial Population Estimator (GSPE; ver Hoef 2002) has been used by the Alaska Department of Fish and Game (ADFG), US Fish and Wildlife Service (USFWS), NPS, and ARCN parks. Details are given in the form of SOPs. The measurable objective is to determine changes in abundance, distribution and composition of moose in ARCN. Among the five parks, eight survey areas have been defined based on historical, ecological, and economic considerations, which vary in size from 4,000 mi² (10,360 km²) to 6,500 mi² (17,834 km²). Surveys occur every four to eight years depending on moose densities and subsistence use of the management area. Throughout most of Alaska, the majority of moose surveys are conducted during the early winter (mid-October to early-December) when both population abundance and sex composition data can be attained. Unfortunately, unreliable snow conditions and poor weather during early winter often prevent accurate population estimation within ARCN parks during this period. Thus, surveys will be conducted in the spring to estimate population abundance only. To estimate population abundance four or five aircraft, with pilots experienced in wildlife surveys and an experienced observer in each aircraft, are needed for approximately four or five days to survey a 4,000 mi² (10,360 km²) area of western arctic Alaska. Data are collected, analyzed and stored according to SOPs outlined in this paper.

Acknowledgments

The authors would like to acknowledge the biologists and statisticians with the Alaska Department of Fish and Game who, over many years, have developed and tested the methods of surveying moose in Alaska and have developed the methods to analyze the resulting data. We thank Marci Johnson for her helpful comments while developing this protocol. We thank the many aircraft pilots who have been an integral part of Alaskan moose surveys, biologists and others who have served as moose survey observers, and on-the-ground personnel who have helped provide safe working conditions for conducting these surveys.

Background and Objectives

This document is the Moose Monitoring Protocol for the Arctic Inventory and Monitoring Network (ARCEN). ARCEN contains five units of the U.S. National Park Service: Gates of the Arctic National Park and Preserve (GAAR), Noatak National Preserve (NOAT), Cape Krusenstern National Monument (CAKR), Kobuk Valley National Park (KOVA) and Bering Land Bridge National Preserve (BELA). This document explains the monitoring methods and objective for moose monitoring within ARCEN. This document provides a narrative for the protocol and companion Standard Operating Procedures (SOPs), which provide specific details of the protocol.

Issues Being Addressed and Rationale for Monitoring Moose Populations

The ARCEN has adopted a holistic view of network ecosystems and monitor the major drivers of ecosystem change, and in part, responses by plants and animals. Vital Sign monitoring of vertebrate species within ARCEN parks includes those of specific interest to each park. Moose (*Alces alces*) are one such species for the ARCEN in part because they are an important part of the ecosystem in each network park. Moose are considered good indicators of long-term habitat change within ecosystems because they require large quantities of resources from their habitat year-round, and populations have the potential to respond to long-term changes in resource conditions (Van Ballenberghe and Ballard 1998, Peek 1998). Moose are crucial to many subsistence communities as a primary source of food that may be harvested on most National Park Service (NPS) land in Alaska, in addition to being harvested by the general public on NPS Preserve lands. Moose are a keystone species in northwestern Alaska, and are of great ecological and management importance. Moose are important to people from both consumptive and non-consumptive viewpoints.

The non-consumptive opportunities that moose provide for viewing and photography in Alaska are probably unequaled anywhere else in the world (Van Ballenberghe 2004). People travel from all over the world to visit national parks in Alaska and one of the primary goals of many visitors is viewing and photographing wildlife, particularly the large mammals found in northwestern Alaska. It is the responsibility of the NPS to ensure that opportunities like these remain unimpaired for future generations. The Vital Signs Monitoring program, such as ARCEN, is one tool NPS is using to fulfill that responsibility.

Moose may be harvested by people throughout all of ARCEN park lands. General hunting is allowed under state regulations throughout all National Preserves in Alaska, and subsistence harvest by qualified residents is allowed within 12 of 13 National Park units created by the Alaska National Interest Lands Conservation Act of 1980 (ANILCA), including the five ARCEN units (GAAR, NOAT, CAKR, KOVA, and BELA). ANILCA mandates that harvest of fish and wildlife be consistent with the conservation of natural and healthy populations within lands managed by NPS. Definition of “natural and healthy” has not been finalized, but in general are defined as stable and continuing populations that are not driven by human harvest or human-caused change (NPS 1998). It is become the responsibility of the NPS, in conjunction with its partners, to monitor moose populations throughout ARCEN.

Annual and/or long-term changes in moose habitat brought on by wildland fire, unusual weather conditions (drought or deep snow), changes in soils, changes in water quality could all have potentially dramatic effects on moose forage quality (e.g., secondary plant compounds) and quantity, which in turn could cause dramatic changes in moose population size or distribution (Maier et al. 2005, Brown 2011, Joly et al. 2016). ARCN monitors several other vital signs that can be linked to or integrated with the moose monitoring data in order to develop a contextual framework of ecosystem function.

Robust estimates of population size, rate of change, and recruitment are crucial to making informed management decisions regarding any harvested wildlife population. The aerial survey procedures described in this protocol should yield minimally-biased, sufficiently-precise estimates of moose population parameters to allow managers to make intelligent, informed decisions regarding moose management in ARCN.

Information gained from monitoring moose in ARCN will be fully integrated with other vital signs monitored in ARCN. Vital sign data such as vegetation structure and composition will provide data on willow and other forage plants that moose depend on. Weather data, predominately snow depth, can be used as an indicator of winter severity and can be compared to changes in the moose population. Fire data (history and severity) can also be correlated to distribution and population size of moose within ARCN.

Measurable Objective

There is one primary objective for the monitoring described in this protocol:

1. Estimating abundance of moose within the survey areas in ARCN

Historical Development of Moose Monitoring in Alaska

Various survey techniques have been used for estimating moose populations across North America, including counts of moose pellet groups (Neff 1968, Timmermann 1974, Franzmann and Arneson 1976), aerial quadrat sampling (Evens et al. 1966), aerial quartile density surveys (Croskery 1975), line transect sampling (Burnham et al. 1980), and aerial indexes of relative abundance based on the number of moose seen per flight hour (Gasaway et al. 1979, Gasaway et al. 1981, Gasaway et al. 1983). Stratified random sampling was first used in November 1978 to estimate moose abundance in Alaska (Gasaway et al. 1983) and was continually refined, published in 1986 (Gasaway et al. 1986), and evolved into the standard technique employed by most agencies in Alaska through the late 1990s.

In the late 1990s, Jay Ver Hoef (Alaska Department Fish & Game) developed a modification to the Gasaway method. He developed the Geo-Spatial Population Estimator (GSPE; Kellie and Delong 2006), which uses spatial statistics (finite population block kriging). The technique defines the individual sample units on a grid of sample units based on minutes of latitude and longitude, rather than landmarks discernable from the air (e.g., rivers, creeks ridgelines) and uses GPS devices in the aircraft to navigate the borders of the units (Ver Hoef 2001, 2002).

Sampling Design

Rationale for Selecting this Sampling Design Over Others

The GSPE technique developed by the Alaska Department of Fish and Game (ADFG) has evolved into the standard for measuring moose abundance in Alaska and is the technique most often used by ADFG and most federal agencies in interior Alaska and the Yukon, Canada. The GSPE method developed by Jay Ver Hoef (2002) meets five necessary criteria: (1) it produces an unbiased estimator of moose abundance; (2) it provides an adequate level of precision around that estimate; (3) it is a realistic, practical survey technique to be used over very large, remote, roadless areas, including flat and mountainous terrain; (4) it has analytical software available for consistent, error free calculations; and (5) it is affordable. In addition, the GSPE method has several advantages over previous survey designs (i.e., stratified random sampling, Gasaway et al. 1986) including (1) estimation of moose numbers in small areas that are nested within larger survey areas, (2) increased precision, and (3) greater flexibility in sample design. Other advantages of using the protocol described here are that results are directly comparable to many other surveys widely distributed in space and time throughout Alaska and the Yukon, and all surveys are based on the same sampling grid of 2 minutes of latitude and 5 minutes of longitude statewide, allowing easy integration and collaboration with other agencies and surveys. This technique focuses on estimating population size, but the other desired parameters (rate of population change, distribution, sex and age composition, and recruitment) are easily calculated from the data required to estimate population size.

Identifying the Survey Area across the five ARCN parks, eight moose survey areas have been defined based on ecological, economic, historical, and cultural considerations (Figure 1; see also SOP #2). Economic and logistical considerations have limited the overall size of each survey area from 4,000 mi² to 6,500 mi² (17,000 km²) within each park. Funding for surveys comes directly from each parks' base funds. Moose survey areas were placed within each park with the idea of utilizing other vital sign data to help put moose population trends into context. These survey areas are not large enough to make park-wide inferences, but are sufficient to monitor moose populations in large portions of each park. The survey areas will exclude areas-of poor moose habitat.

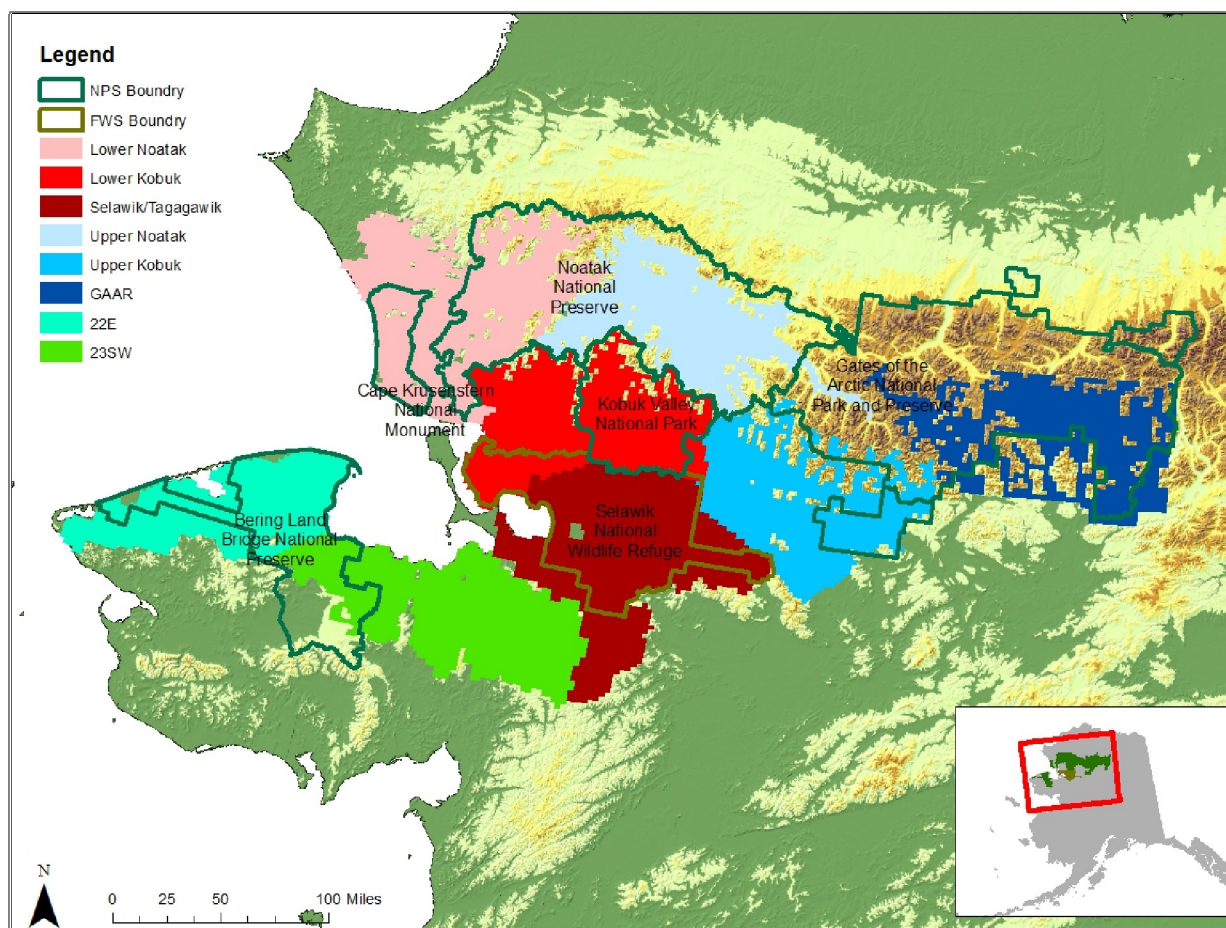


Figure 1. Moose survey areas throughout ARCN. The core areas (Lower Kobuk, Lower Noatak, and Selawik/Tagagawik) are highlighted in red and the outer areas (GAAR, Upper Kobuk, Upper Noatak, and 22E, 23SW) are highlighted in blue or green.

Population Being Monitored

Throughout most of Alaska, the majority of moose abundance surveys are typically conducted during the early winter (mid-October to early-December) when sex and specific age composition data can be attained. Aerial moose surveys require adequate snow cover to maximize moose sightability and a reasonable amount of daylight to make aircraft use economical. In the ARCN parks and surrounding areas, adequate snow cover for an early winter survey is often unreliable, as is the flying weather. Therefore, historically most moose surveys estimating population abundance within ARCN parks are conducted during the spring (late February – early April) when snow conditions improve sightability and daylight is increasing. Thus, this protocol addresses population abundance and distribution only. Sex/age composition may be covered by other monitoring efforts.

To estimate moose abundance and distribution within the ARCN parks eight different areas are surveyed. Three of the areas are considered “core” areas because of their relatively higher moose densities and their importance to local subsistence communities. The core areas are the Lower Noatak, Lower Kobuk, and Selawik and Tagagawik (Figure 1, Table 1). The remaining five areas are considered “outer” areas, and are the Upper Noatak, Upper Kobuk, 22SW, 22E, and Gates of the

Arctic (GAAR, Figure 1, Table 1). The boundaries of the survey areas are largely defined by major drainage systems and historic collaring projects. Future studies using GPS-collaring data could be considered to help refine survey boundaries if need be or to estimate sightability correction factors (Seaton 2014).

Table 1. List of moose survey areas within ARCN and relevant information.

Survey Area	Size (mi ²)	Size (km ²)	Survey Month
Lower Noatak ¹	6,405	16,588	Mar/Apr
Upper Noatak ²	4,468	11,603	Mar/Apr
Lower Kobuk ¹	5,338	13,825	Mar/Apr
Upper Kobuk ²	5,057	13,098	Mar/Apr
Selawik & Tagagawik ¹	6,559	16,988	Mar
23SW ²	5,767	14,937	Mar/Apr
22E ²	3,941	10,207	Feb/Mar
GAAR ²	5,106	13,225	Mar

1- Indicates core areas

2- Indicates outer areas

Moose in some populations are known to move long distances in fall and spring. The spring movements do not typically begin before mid-April and the fall movements are typically completed by mid to late October so are not a factor regarding most surveys (Gasaway et. al. 1983, Ballard et. al. 1991, Hundertmark 1998, Joly et al. 2015). Nonetheless, the timing of surveys should be consistent across years to improve interpretation of results. The population being sampled includes moose that are within the survey area boundary during the time that the survey is being conducted, usually March/April.

Sampling Frequency and Intensity

Survey frequency depends on historical, cultural and budget considerations. Areas defined as core areas because of their relatively higher densities of moose and value to local communities for subsistence resources will be surveyed more often than outer areas. Population abundance surveys within the core and outer areas will be conducted approximately once every four and eight years, respectively. This schedule will be adequate to detect a change in abundance in the core areas. Therefore, during an eight year rotation ARCN will survey all of the core areas twice and each of the outer areas once (Appendix B).

Identifying change in population size will be directly related to the precision of the individual estimates. The more precise the individual estimates, the smaller the change in population that can be detected. The goal of the sampling strategy is to achieve less than a 20% confidence interval at an alpha of 0.1, which will allow detection of population increases of 50% or decreases of 33%. Past ARCN moose surveys that achieved less than 20% CI surveyed, on average, 22% of the survey area, while sampling 46% and 17% of the high and low stratification units, respectively. A comparison of

the 90% confidence intervals around the point estimate will be used to determine whether a biologically-important difference exists between any two survey estimates.

Field Methods

Survey Preparations and Schedule

Timing of moose surveys revolves around two primary factors: snow conditions and daylight, which generally restricts the area that may be covered in a day. Several months prior to each survey, the Vital Sign lead should schedule aircraft and pilots. This may seem early, but the more experienced pilots are scheduled for moose surveys far in advance and the more experienced the pilots are, the better and the safer the survey is (See SOP #1 for aircraft and pilot requirements). One observer should be lined up for each aircraft, and at least one alternate pilot and observer should be made aware that they may be asked to participate in the survey should the need arise. If an aerial stratification of survey units will be performed, an additional aircraft (typically C-185 or C-206) and 3 observers should be scheduled. The biologists and all observers should review this entire protocol, including all of the SOPs, Gasaway et al. (1986), and Kellie and DeLong (2006). Biologists should pay special attention to the tasks described in SOP #1, “Survey Preparation” and SOP #2, “Selecting the survey area.” Observers need to review SOPs #2 and #3, “Survey methods and Flight Patterns”. The PI needs to make two full map sets of the sample units for each aircraft (one for the pilot and one for the observer) and two extra copies, one of which can be used as a master map at the base camp for the survey. Numerous copies of the Abundance Moose Survey Data Form (Appendix A) should be made. Two copies per surveyed unit will be adequate.

Before the abundance survey is flown, the survey area needs to be stratified into high and low strata and a random pick of sample units made for each stratum. Stratification can be handled in one of three ways: 1) a stratification flight can be made immediately before the survey begins; 2) prior knowledge of moose distribution in the area from past surveys can be used to stratify the area in the office using GIS (see SOP #2, “Selecting the Survey Area”), which is commonly referred to as the ‘office’ or ‘desktop’ stratification; and 3) a variation of the ‘desktop’ stratification is to use prior knowledge of moose distribution and assume that a large part of the total survey area is in one (usually low density) stratum. This assumption reduces the need to stratify that part of the survey area with an aircraft. The assumption is that there is little variation in moose abundance between sample units within the low density stratum.

Prior to any aerial stratification or the survey itself, adequate snow cover (SOP#1) must exist throughout the survey area. A reconnaissance flight may be needed if no other way to determine snow cover exists. Air taxi operators and local residents are possible sources of information regarding snowfall and snow cover. Also, data from climate stations might be available to help assess snow conditions in the survey area.

Once these preparations are made, the survey itself can begin. It should be completed as quickly as possible, but the GSPE technique does allow the survey to be spread out in time and is therefore more flexible than the older Gasaway et al. (1986) method. Depending on habitat types, day length, snow conditions, and the amount of ferry time to get to assigned survey units, a single aircraft can sample between 6 and 12 units per day. With four or five aircraft flying on the same survey, it is not uncommon to complete 45 or 70 units per day. On larger survey areas, 240 surveyed units is a

reasonable goal and typically takes at least five or six good weather days with five aircraft. When scheduling aircraft, at least three to five days should be factored to account for bad flying/surveying weather, possibly more in some areas. Unfortunately, October and November often have some of the worst aviation weather for northwestern Alaska; however, March often has favorable weather.

Conducting the Moose Survey: Gasaway et al. (1986), Kellie and DeLong (2006), and DeLong (2006) go into great detail on moose survey methods, and these should be thoroughly reviewed. Sections include search effort, flight patterns, required snow conditions, etc. The primary difference between flying a Gasaway et al. (1986) survey and the GSPE survey (Ver Hoef 2001, Ver Hoef 2002, Kellie and DeLong 2006) is that the GSPE utilizes smaller grids as sample units based on latitude-longitude and are flown more intensively (about eight minutes per square mile versus four or five minutes per square mile) with the assumption of 100% moose sightability. Units should be flown as efficiently as possible and two or three adjacent units can be flown concurrently. Flat terrain can be flown in transects 0.2 miles apart (SOP #3, Figure 1). Steeper terrain requires flying elevational contours. Survey aircraft should fly 300 to 400 feet above the ground at about 60-70 miles per hour. It is not uncommon to spend 45-60 minutes on a single survey unit with significant amounts of thick vegetation or numerous moose. Units with tall or thick spruce trees will require more survey time than units with more open vegetation. Fresh moose tracks in the snow are valuable in helping to find moose in the survey unit. Coordinates for each moose group seen, regardless of whether it is in a sampled survey unit or not, are recorded from the aircraft's GPS or waypointed by the observer. For each survey unit, information is collected describing search conditions (e.g. snow age and cover, light conditions, and habitat), temperature, start/end time, and pilot/observer. The latitude and longitude is recorded for each group of moose observed along with the number of adults, calves, and unknown moose. Each evening after flying for the day, all datasheets from each plane are collected and the data entered into the GSPE software for geo-spatial analysis (DeLong 2006).

Data Management

Overview

The success of the ARCN moose monitoring program hinges directly on maintaining and sustaining a high quality dataset in perpetuity. To meet the challenge the program has invested time and energy up front developing this monitoring protocol, its related standard operating procedures and a robust data management system. This system ensures that data are collected consistently, processed correctly, and managed well to meet the present and future analytical objectives of park scientists.

NPS Standards for Data Quality

Director's Order #11B 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 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 #19). 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 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.

Records Management

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

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 2005 (NPS, 2005) 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.

System Architecture

The ARCN moose monitoring program will follow the guidance provided by the Inventory and Monitoring Program (NPS 2008a, Frakes et al. 2015) and the ARCN data management plan (NPS 2008b). The heart of the system is a Microsoft SQL Server database housed at the Fairbanks Administrative Center in Fairbanks, Alaska (Figure 2).

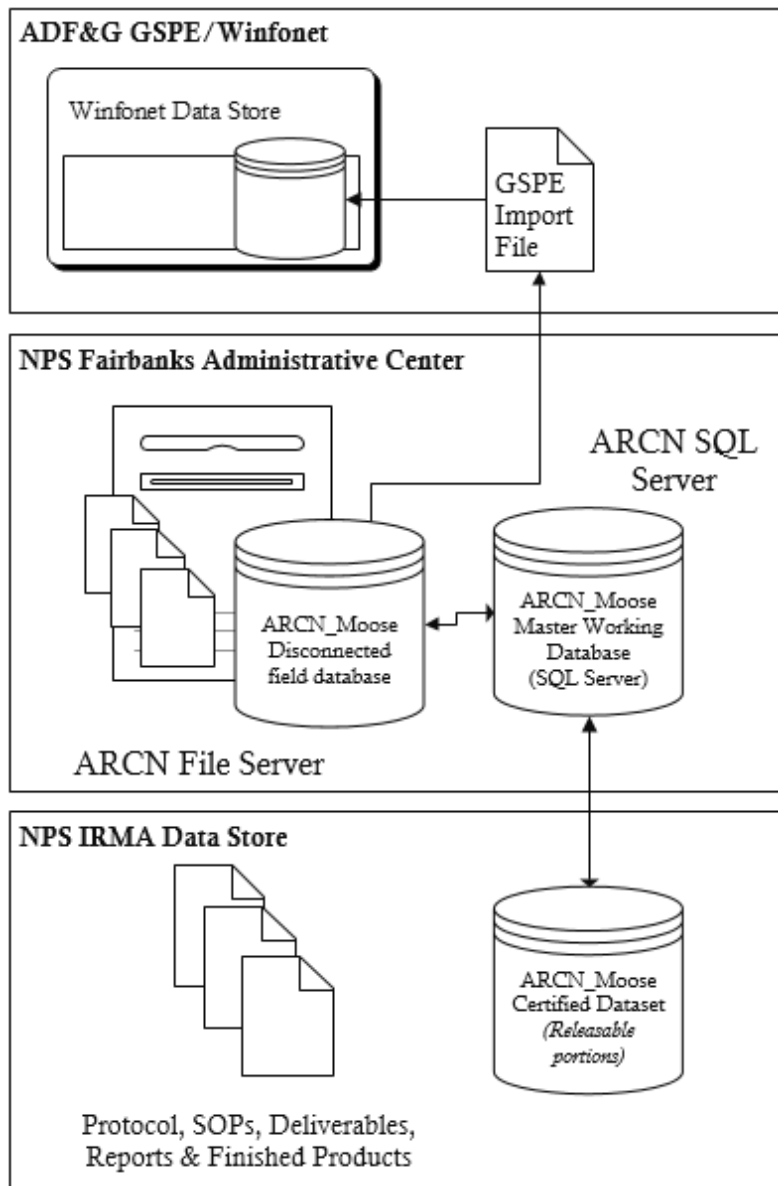


Figure 2. Moose monitoring data management system architecture. From the bottom, a master Project reference in the IRMA Data Store organizes multiple assets including the protocol, SOPs, data deliverables and other products including certified data. Working files are stored on the ARCN moose monitoring shared drive. A master SQL Server database stores data. A disconnected field database is used during aerial moose surveys. The field database file serves as an input file for GSPE analytical software.

Working files such as field data deliverables, reports in progress, correspondence, etc. are stored in a designated moose monitoring directory on the ARCN file share drive. Finished products including the moose protocol, SOPs, reports, processed data deliverables and certified data are documented and the releasable portions archived in the NPS Integrated Resource Management Applications (IRMA) Data Store (<https://irma.nps.gov/DataStore/>). A single authoritative Project reference exists in the Data Store (<https://irma.nps.gov/App/Reference/Profile/2222140>, Figure 3) to which all subsequent

products are linked. This system of linked references in the Data Store assures that future scientists can be given a single Data Store reference code and discover all legacy materials in a well-organized and documented system of references.

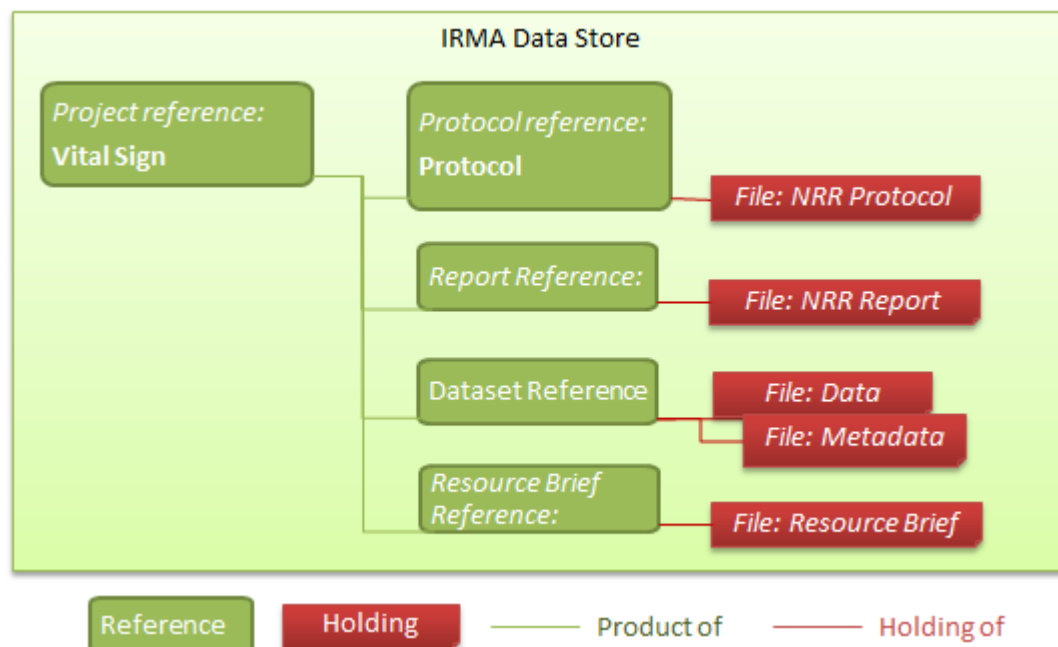


Figure 3. Moose monitoring Project reference architecture in the IRMA Data Store.

GSPE software (Delong 2006, <https://winfonet.alaska.gov>) is a critical analytical tool used by the ARCN moose monitoring program (Figure 2). Certified data from the ARCN_Moose master database is exported from database views in the specific formats required by GSPE and uploaded for analysis. Moose monitoring data is stored in both the ARCN_Moose database (IRMA Data Store, <https://irma.nps.gov/App/Reference/Profile/2222140>) hosted by the NPS as well as GSPE/Winfonet, but the single authoritative repository for moose monitoring data is the ARCN_Moose database.

Data Management Life Cycle

Data management for the moose monitoring program will proceed through an ongoing life cycle as shown in Figure 4 (NPS 2008b). 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).

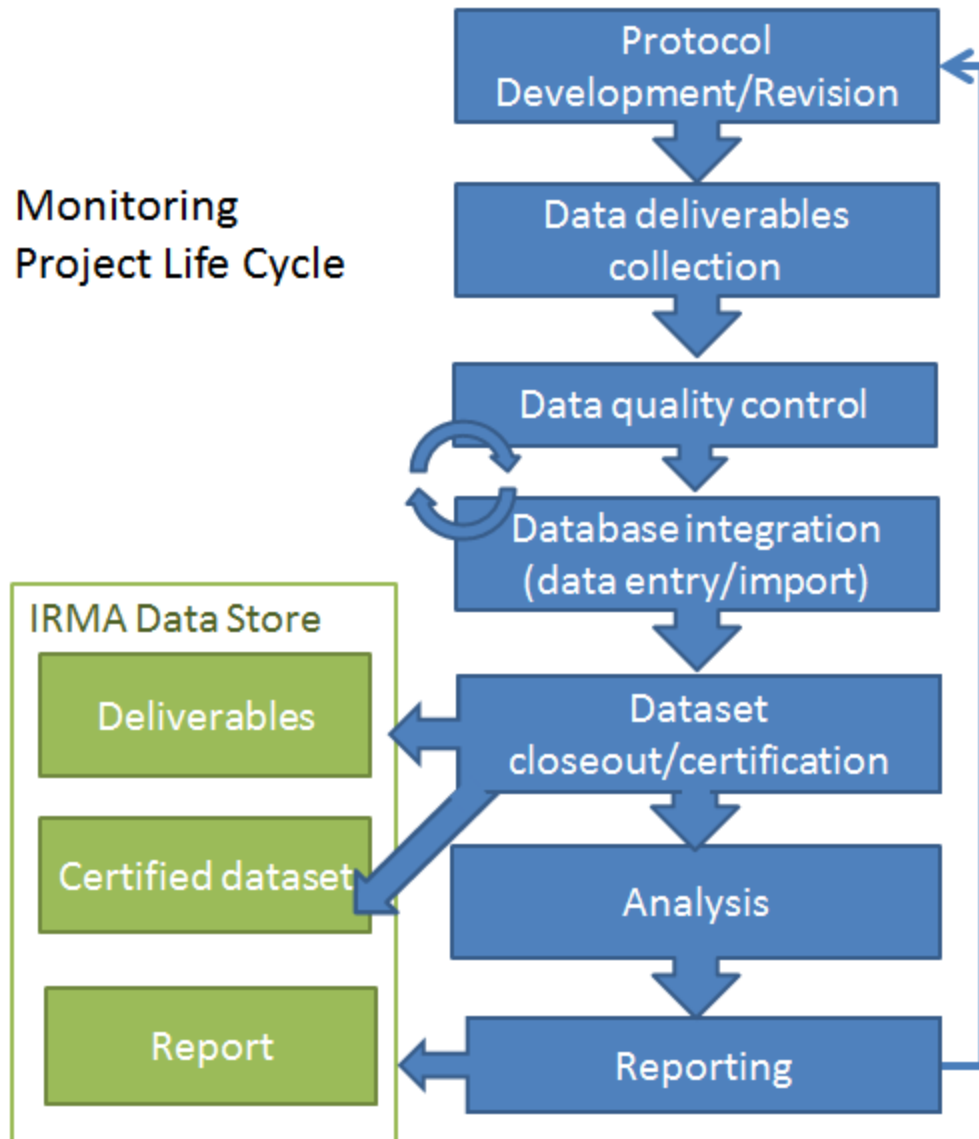


Figure 4. Long term monitoring project data management life cycle.

Most data processing occurs in the moose monitoring directory of the ARCN Inventory and Monitoring (I&M) shared drive. Mission critical files are documented and published to the IRMA Data Store, the sole authoritative repository for moose monitoring products (Figure 5).

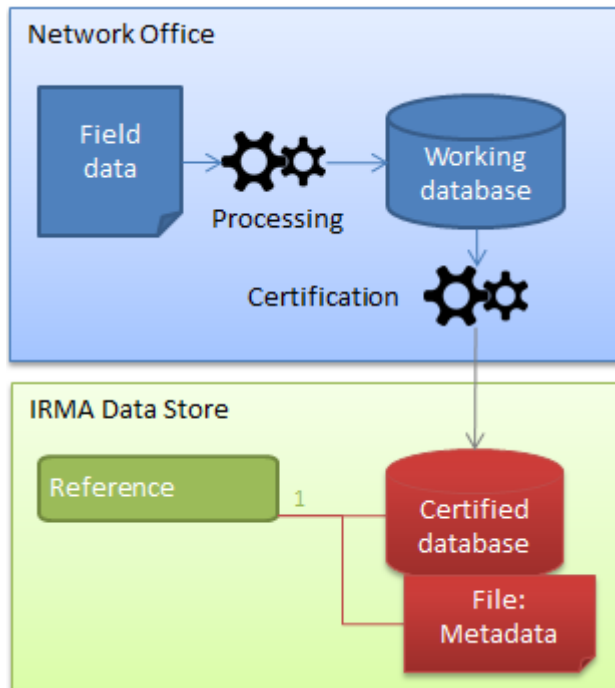


Figure 5. Field data deliverables are collected, processed, integrated with the master moose monitoring database and then certified for analysis. A certified snapshot of the moose monitoring dataset is published with metadata on an annual schedule to the IRMA Data Store.

Data Sensitivity Statement

I&M has a policy on sensitive data:

Data sets that contain sensitive information should be published in redacted form, or in total with limited access. In the Data Store, the reference should always be visible to the public; however, the associated data sets can be limited to internal distribution to appropriate audiences. Access should not be restricted beyond what is required—data must be available for science-based decision making by park personnel. Data sets (sensitive or not) may be published to the Data Store and restricted to “internal use only” for a period of up to two years. This provides time for IMD staff to professionally publish on the data before their public release (NPS 2016).

The ARCN/CAKN moose monitoring protocol defines the collection of sensitive data and requires special handling procedures.

The justification for this declaration of sensitivity is that the data deals with ‘rare, threatened, endangered, or commercially valuable species’. The sensitive portions of the moose monitoring dataset are specific locations (latitude/longitude) of moose sightings. Such geographic coordinates must be removed from publicly available datasets. 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 files in the IRMA Data Store must reflect that the associated data are sensitive. 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.

Data Deliverables Schedule

The ARCN moose monitoring program collects a specific set of data deliverables in support of the protocol's analytical requirements (Figure 6, Table 1, SOP #4). The deliverables schedule describes the data objects that are collected on a repeating schedule, the standard operating procedures that guide their processing, and the actors responsible for their fulfillment. Deliverables are collected in the field, processed and integrated with the master database in the moose monitoring directory of the ARCN shared drive. Certified deliverables are archived privately in the IRMA Data Store in case they are needed again in the future. Certified data is exported from the master database and the releasable portions published to the IRMA Data Store.

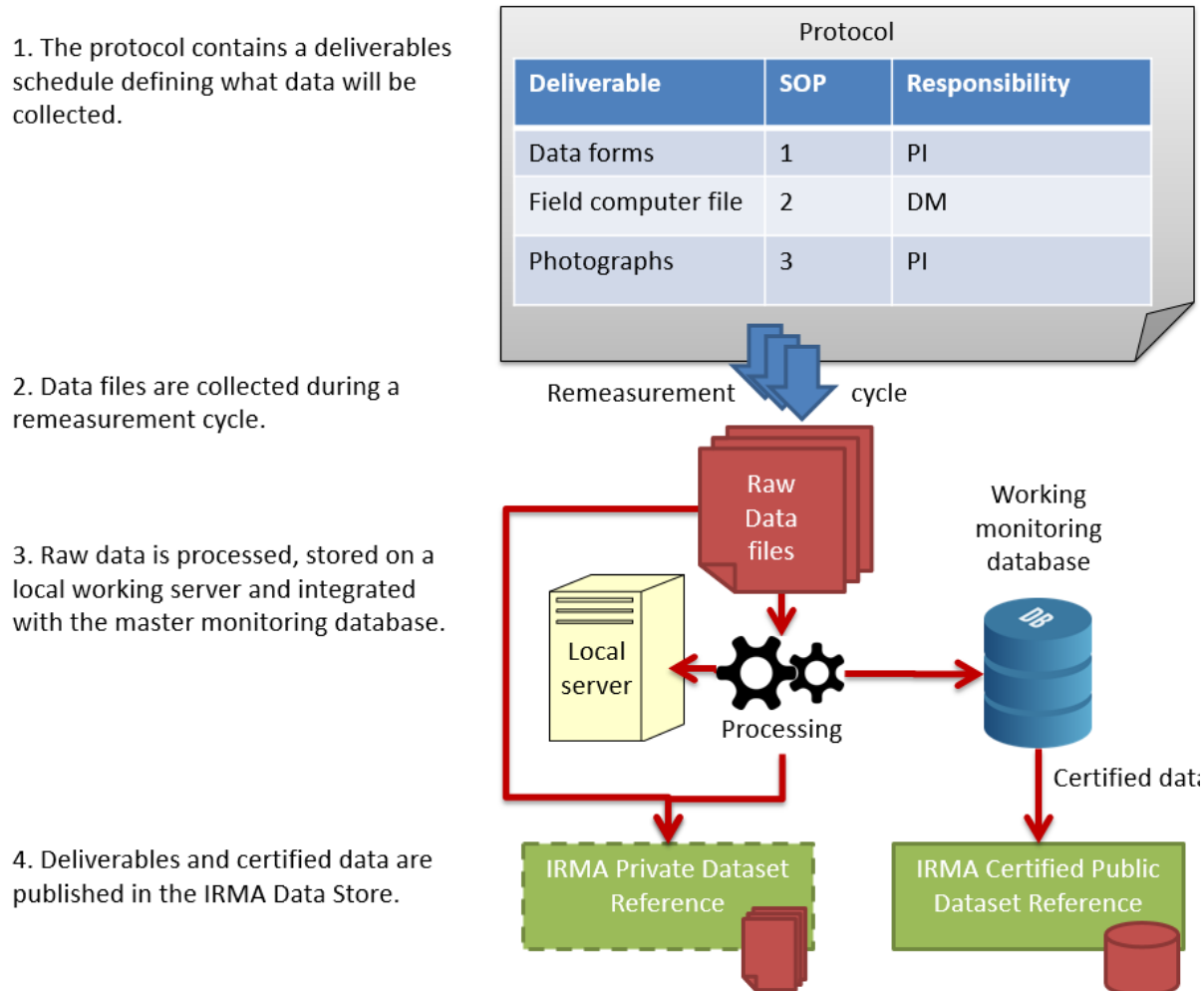


Figure 6. Data deliverables processing and archival plan.

Moose monitoring data deliverables are collected according to standard operating procedures and archived with documentation/metadata on a regular schedule in the IRMA Data Store. Consult SOP#4 for the schedule and specific data management procedures.

Roles and Responsibilities

Moose monitoring team members must work collaboratively to assure the quality of the communal dataset is maintained at a high level.

Project Leader

- Ensures that the moose 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 is 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 moose monitoring dataset for analysis and publication
- 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 moose 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 moose Vital Sign assures high data quality by proactively deploying a system of quality assurance safeguards and a consistent framework of administrative and technological quality control procedures. This system includes:

- Standard operating procedures designed to maintain consistent data collection methods and minimize the introduction of errors during data processing and database integration.
- 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.

Quality Control

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

- Cross-summing checks
- Visual data verification
- 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.

Product Archival and Documentation

Director's Order 19 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 (SOP#4). 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 snapshots of all moose monitoring databases (a SQL script that can recreate the entire database and all the data within it).
 - Photographs
 - Hard copies and scans of paper data collection forms
- Ancillary file storage on the ARCN file server
- SQL Server snapshot backup packages that can be restored to a server with low latency.

IRMA Data Store

The NPS IRMA Data Store is the primary organizational repository and publication platform for information related to the moose monitoring program. The moose Vital Sign has a single master IRMA project reference (<https://irma.nps.gov/App/Reference/Profile/2222140>) to which all products are related (Figure 3).

The public Vital Sign web page covering moose 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 are published in the NPS Natural Resource Report publication series (<https://www.nps.gov/im/publication-series.htm>) 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 3) and notify Network staff of their presence.

Data Publication

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

The moose Vital Sign will have a single public dataset reference in the IRMA Data Store to which certified data will be published (Figure 3). This reference will be the only authoritative data source available to the public.

Resource Brief

The I&M resource brief is the primary outreach document for the moose 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 3).

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 3).

Metadata

All project datasets, including spatial and non-spatial data, are archived in the IRMA data store with metadata (NPS 2005, Figure 3). The mandate for adequate metadata comes from Director's Order #11A: *"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."*

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 procedure's 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.

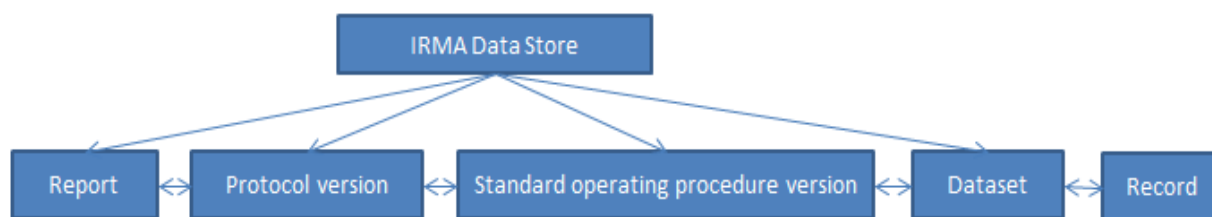


Figure 7. Each informational component informs and is informed by other components. Discovery of one component leads to discovery of all other components in a formalized data management chain of custody.

Database design

The moose monitoring program will have a single, authoritative database built according to I&M standards (NPS 2016). A disconnected field database or spreadsheet (Ver Hoef 2001) that integrates with GSPE software will be used for data entry in the field. GSPE software is currently only available through ADF&G's website (at www.winfonet.alaska.gov). This GSPE field data deliverable is specified in SOP #4 and is processed and integrated with the master moose monitoring database upon return to the office.

The design of the field data entry file is a simple flat file with each row corresponding to an individual survey unit and the moose seen in it. The fields are made up of the total moose seen in each unit, a breakdown of the sex and age composition of moose seen, and the ID number, size and location of the sample unit.

Data and Information Security

Moose monitoring program data are maintained on a network file share and SQL Server database located in the Fairbanks Administrative Center (FAC) in Fairbanks, Alaska. The certified database content is backed up to off-site storage and also copied to a database server at the NPS Natural Resource Stewardship and Science Directorate (NRSS) in Denver, Colorado. The NRSS and FAC use enterprise-level business continuity processes to maintain their version of the moose database. In the event of catastrophe at one site, the original data may be restored from the other.

Closeout

Closeout is the part of the moose monitoring data management life cycle through which seasonal data collection deliverables (SOP #4) are archived in the IRMA Data Store. Specific closeout procedures are found in SOP #4. Closeout happens after a data collection cycle when data files have been collected, processed and integrated into the main monitoring database. After field data are integrated with the master monitoring database they are archived as holdings of private IRMA Dataset References (SOP#4). Closeout is complete when the IRMA Dataset's holdings match the deliverables schedule. After closeout all permissions are removed from the IRMA Dataset reference except for the project leader and data manager. The dataset reference will then be linked to the main moose monitoring IRMA Project reference so that it becomes discoverable within the NPS.

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.

Certification

Certification is the phase of the moose monitoring data management life cycle where the principal investigator formally attests that the Vital Sign's dataset is ready for analysis. Certification also affirms the integrity of the scientific, administrative and technical support structure of the moose monitoring program. Certification procedures are defined in SOP#4. The principal investigator's signature on the data certification form indicates:

- 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 in the IRMA Data Store.
- 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 published.

A data certification form is signed by the principal investigator during certification after the dataset is complete. A copy of the form is then attached to the Vital Sign's public IRMA Dataset reference.

Analysis and Reporting

See SOP#5 Data Analysis and Reporting.

Personnel Requirements and Training

Roles and Responsibilities

A designated NPS wildlife biologist will be the lead for implementing this monitoring protocol for the ARCN. ARCN biologists and staff participate and assist as needed. Data management is the shared responsibility of the Vital Sign lead and the network data manager.

The Vital Sign lead is responsible for survey planning and logistics, data collection, data entry, data verification and validation, as well as data summary, analysis and reporting. The network data manager is responsible for data archiving, data security, dissemination and database design. The data manager, in collaboration with the park biologist, also develops data entry forms or electronic data entry systems and other database features as part of quality assurance and automated report generation. The data manager is responsible to see that adequate Quality Assurance/Quality Control (QA/QC) procedures are built into the database management system and assisting the PI to make certain appropriate data handling procedures are followed.

Observers are typically the biologists involved in the survey. Other observers are asked to fly as they are needed, from NPS or other agency staff with experience as observers on past moose surveys or with experience as observers in other aerial wildlife surveys. As surveys typically only last one or two weeks, hiring observers specifically for the moose survey is not necessary.

Qualifications and Training

The most essential components for the collection of credible, high-quality data from moose surveys are experienced, competent pilots and observers. Every effort should be made to get the most experienced pilots and observers possible, but the reality is that there will likely be a mixture of both, and the least experienced observers should be teamed up with the most experienced pilots and vice versa. Pilot's flight hours of experience should be evaluated by the amount of time in low level wildlife survey work (moose surveys, radiotracking or any work that involves spotting and observing wildlife from aircraft), not simple point to point flying. The experience of the pilots is far more important than the experience of the biologists or the observers.

The quality of the pilot/observer teams will determine the quality of the data. Time should also be invested in training new observers for future surveys by sending new observers out with the most experienced pilot. If a new, inexperienced observer must be used, the only way to train them is to review the procedures with them and the pilot (preferably the most experienced pilot available). At the end of the first day, the pilot can then give the Vital Sign lead a critique of the observer's abilities and make adjustments as needed. Fortunately, flying as an observer on a moose survey is not that difficult and, with some coaching, can be accomplished by most people with some wildlife background. Other factors, such as air sickness, can reduce the quality of the data and must be considered.

Operational Requirements

Annual Workload and Field Schedule

Moose abundance surveys will begin no sooner than late-February and extend no later than late-April. Snow and weather conditions will dictate when the survey can be completed. Approximately five to seven days are required to complete a moose abundance survey of approximately 4,000 mi² (10,360 km²) with 4 to 5 aircraft. It is proposed to conduct one survey in each of the three core trend areas once every four years in rotation and one survey in each of the five outer trend areas once every eight years in rotation, thus during one in every four years two surveys will need to be conducted (Appendix B). The proposed schedule should be viewed as an overall goal with the understanding that conservation concerns, weather, and funding may require changes in the timing of surveys to meet management needs.

Facility and Equipment Needs

Housing and food for eight to 10 people will be required for seven to 10 days where the survey is based, depending on the size of the survey area, number of planes used, weather and distance from a hub location. Arrangements will need to be made to preheat four or five aircraft simultaneously so all planes can leave at first light in the morning. This requires more forethought and planning in remote field camps (such as Dahl Creek near Kobuk) that are without electricity, which may require a gas generator. Enough aviation fuel will need to be delivered in advance, and a fuel transfer system set up and tested in advance. Remote fuel caches may need to be supplied before it snows. Tie down space for four or five aircraft will be needed. The aircraft should be based as close to the survey area as possible.

Most of the equipment needed in OAS aircraft used in the survey is required by Aviation Management Directorate (AMD) certification and contracting procedures. Aircraft must have functional radios for communication and coordination, an Automatic Flight Following device (AFF), adequate heaters for comfort in cold weather, and functioning GPS units for locating the boundaries of survey units. A very valuable, though not absolutely necessary, piece of equipment is a moving-map GPS unit like the Garmin GPSMAP 296 or iPads with topo maps. The use of both a panel-mounted GPS and a moving-map unit to visually orient the aircraft in the survey unit provides the most efficient means of conducting wildlife surveys on rectangular survey units. Another valuable addition is for the observer in each aircraft to also have a moving map GPS unit for double checking the flight lines relative to the unit boundaries and for storing waypoints of moose groups seen.

Budgets for personnel expenses for fieldwork are assumed to be covered by park base money from the five ARCN parks. Over 95% of the cost for conducting a moose survey is aircraft rental and fuel. The amounts listed in Table 2 are the estimated costs for conducting an abundance moose survey over a 4,000 mi² (10,360 km²) survey area.

Table 2. Estimated costs for conducting a moose abundance survey over a 4,000 mi² (10,360 km²) survey area, assuming no stratification flights. Aerial stratification is likely to add \$5,000 to \$16,000 to the cost. Each contract tandem aircraft adds an additional \$4,500 per 30 hours of survey time over a government fleet aircraft and pilot. Prices based on 2017 rates and does not consider increases due to inflation, changing prices in fuel or aircraft rental.

Itemized Expenditures (2015)	Cost (\$)
Food (housing provided by host park)	2,000
Contract Aircraft 2 for 5 days (45 hrs @ 275/hr)	12,375
DOI agency Aircraft 2 for 5 days (45 hrs @ 125/hr)	5,625
Fuel 810 gallons @ \$8.00/gal	6,480
Total	26,480

Procedure for Revising the Moose Monitoring Protocol and Archiving Previous Versions of the Protocol

Over time, revisions to both the Moose Monitoring Protocol narrative and to specific SOPs are to be expected. Careful documentation of changes to the Protocol, and a library of previous Protocol versions are essential for maintaining consistency in data collection, and for appropriate treatment of the data during data summary and analysis. The MS Access database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected.

The rationale for dividing a sampling protocol into a protocol narrative with supporting SOPs is based on the following:

- The Moose Monitoring Protocol narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol narrative will only be revised if major changes are made to the protocol.
- The SOPs, in contrast, are specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the Protocol narrative. When an SOP is revised, in most cases it is not necessary to revise the Protocol narrative to reflect the specific changes made to the SOP.
- All versions of the Moose Monitoring Protocol narrative and SOPs will be archived in a Protocol Library.

The steps for changing the Protocol (either the Protocol narrative or the SOPs) are outlined in SOP #6, “Revising the Protocol.” Each SOP contains a Revision History Log that should be filled out each time a SOP is revised to explain why the change was made and to assign a new Version Number to the revised SOP. The new version of the SOP and/or Protocol narrative should then be archived in the LTEM Protocol Library under the appropriate folder.

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Appendix A. Moose Abundance Survey Data Form

Page ____ of ____		Revised: 12/15/04			
SEARCH IDENTIFICATION		SEARCH EFFORT	SEARCH TIMES (in minutes)		
Date: _____	SU #: _____	~8 min/mi ² (depends on terrain)	Stop@ _____		
GMU: _____					
Location: _____					
Observer: _____		Stratum: _____	Start@ _____		
Pilot: _____		Area (mi ²): _____	Elapsed _____		
Aircraft Type: _____	Temp (F) _____				
OVERALL SURVEY RATING: ☐ Excellent ☐ Good ☐ Fair ☐ Poor					
SEARCH CONDITIONS					
SNOW AGE ☐ 1. Fresh ☐ 2. < 1 week ☐ 3. > 1 week LIGHT TYPE ☐ 1. Bright ☐ 2. Flat		SNOW COVER ☐ 1. Complete ☐ 2. Some Low veg Showing ☐ 3. Bare Ground Showing LIGHT INTENSITY ☐ 1. High ☐ 2. Medium ☐ 3. Low			
PREDOMINANT HABITAT TYPE IN SU ☐ 1. Open lower elevation, predom shrub, riparian, or wetland ☐ 2. Mixed Open Forest with some shrub understory ☐ 3. Dense Spruce Forest ☐ 4. Dense Deciduous Forest Birch, Aspen, etc. Few Shrubs ☐ 5. Subalpine Shrub ☐ 6. Burn ☐ 7. Open tussock tundra with forested 'stringers' ☐ 8. Other (describe): _____					
CHECK ADDITIONAL CONDITIONS THAT MAY HAVE AFFECTED THE QUALITY OF THE SEARCH					
☐ Classification Errors ☐ Inadequate Snow Cover ☐ Poor Light ☐ Low Clouds or Fog ☐ Uncooperative Pilot ☐ Inexperienced Pilot ☐ Inexperienced Observer ☐ Poor Visibility/Snow on Trees ☐ Inadequate Search Effort ☐ Movement In/Out Of Intensive ☐ Large Number of Moose in Unit (>25) ☐ Problems finding SU Boundaries ☐ Short on Fuel ☐ Movement In/Out of SU ☐ Observer Airsick ☐ Observer Sleeping ☐ Windy/Turbulent ☐ Improper Aircraft ☐ Other (Explain): _____					
Group No.	Adults	Calves	Unk.	Total Moose	Remarks/Waypoint/Lat-Long
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
Survey Summary					
1-13					Total Number of Moose:
14-45					
Total					

Group No.	Adults	Calves	Unk	Total Moose	Remarks/Waypoint/Lat-Lon
14.					
15.					
16.					
17.					
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21.					
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43.					
44.					
45.					

Survey Summary Subtotal					
14-45					

Appendix B. Survey Schedule

Table B1. Moose abundance survey schedule within ARCN. Survey areas highlighted in bold are “core” survey areas, otherwise considered “outer” survey area.

Year	Survey Area	Years since last survey
2001	Lower Noatak (and western Squirrel)^c	NA
2001	Tagagawik	NA
2002	23SW	NA
2003	Upper Kobuk (Old)	NA
2003	22E	NA
2004 ^F	GAAR	NA
2004	23SW	2
2005	Lower Noatak (and western Squirrel)^c	4
2006	Lower Kobuk (and eastern Squirrel)^c	NA
2006	Upper Kobuk (Old)	3
2006	22E	3
2007	Selawik/Tagagawik^c	NA
2008	Lower Noatak (and western Squirrel)^c	3
2009	23SW	7
2010	Upper Noatak	NA
2011	Selawik/Tagagawik^c	4
2011	22E	5
2012	Lower Kobuk (and eastern Squirrel)^c	6
2013	Lower Noatak (and western Squirrel)^c	5
2014	Upper Kobuk	8
2014	22E	3
2015	GAAR	11
2015	23SW	6
2016	Selawik/Tagagawik^c	5
2017	Lower Kobuk (and eastern Squirrel)^c	5
2018	Lower Noatak (and western Squirrel)^c	5
2019*	Upper Noatak	9
2020*	Selawik and Tag^c	4
2021*	Lower Kobuk (and eastern Squirrel)^c	4
2021*	Upper Kobuk	9
2022*	Lower Noatak (and western Squirrel)^c	4

^c “Core” survey areas

^F Abundance survey conducted in the fall

* Proposed survey

Table B1. Moose abundance survey schedule within ARCN. Survey areas highlighted in bold are “core” survey areas, otherwise considered “outer” survey area.

Year	Survey Area	Years since last survey
2023 [*]	22E	9
2023 [*]	GAAR	8
2024 [*]	23SW	9

^C “Core” survey areas

^F Abundance survey conducted in the fall

^{*} Proposed survey

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 953/148298, September 2018

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

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