



Moose Monitoring Protocol for the Arctic Inventory and Monitoring Network

Data Quality Standards

Natural Resource Report NPS/ARC/NRR—2018/1704



ON THE COVER

Moose walking through a meadow in Gates of the Arctic National Park and Preserve during March.
NPS photograph by Kyle Joly.

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Contents

	Page
Figures and Tables	v
Introduction.....	1
Protocol Overview	1
Conceptual Framework for Monitoring	1
Protocol Activities	3
Sampling Design.....	5
Data Quality Objectives.....	9
Measurement Quality Objectives and Performance Standards	10
References.....	11

Figures and Tables

	Page
Figure 1. Moose survey areas throughout ARCN.....	6
Table 1. List of moose survey areas within ARCN and relevant information.....	6
Table 2. Moose abundance survey schedule within ARCN.....	7
Table 3. Quality Objective table for moose monitoring protocol.....	10

Introduction

The purpose of this report is to document the standards used by the Arctic Network (ARCN) Inventory and Monitoring Program for activities related to the collection, processing, storage, analysis, and publication of monitoring data as described in the Moose Monitoring Protocol for the Arctic Inventory and Monitoring Network (Sorum et al. 2018). The policies and procedures documented in this quality-assurance plan for activities follow the quality-assurance plan for other monitoring activities conducted by ARCN and supplement the National Inventory & Monitoring Division Quality Management Plan. The Standard Operating Procedures provide detailed protocol/program activities associated with moose monitoring. This plan serves as a guide for all personnel who are involved in protocol/program activities and as a resource for identifying memoranda, publications, and other literature that describe associated techniques and requirements in more detail.

Protocol Overview

This protocol outlines how monitoring data will be collected, managed and reported for the moose “Vital Sign”, as part of the NPS Vital Signs Inventory and Monitoring program and as described in the ARCN Monitoring Plan (Lawler et al. 2009). References, such as, *Conducting the Moose Survey* Gasaway et al. (1986), Kellie and DeLong (2006), and DeLong (2006) go into great detail on study design, data collection methods, and analytical protocols.

Conceptual Framework for Monitoring

The prioritization of the moose vital sign was based on park management priorities; the role of moose as a good indicator of long-term habitat change within park ecosystems (van Ballenberghe and Ballard 1998, Peek 1998); the importance of moose for sport and subsistence hunting and implications for harvest management; and linkages with other vital signs including climate, snow, terrestrial vegetation, and other herbivore and predator species (Lawler et al. 2009). The NPS is mandated by the Alaska National Interest Lands Conservation Act (ANILCA 1980): (1) “to protect . . . populations of . . . moose” (Section 201 (4)(a)); (2) “to provide the opportunity for continued subsistence uses” (Section 801 (4)); and (3) “[to conserve] natural and healthy populations” (Section 814(1)). Moose can be legally hunted on park and preserve lands by federally qualified subsistence users, and sport hunting is permitted in BELA and NOAT and preserve portions of GAAR. Moose are an important game and subsistence species and populations are monitored throughout Alaska to provide continued harvest opportunities (Alaska Department of Fish and Game 2008). For these reasons, identifying and monitoring changes in moose populations are of particular management concern to the parks where moose occur.

Protocol Activities

This protocol covers ARCN's main monitoring objective for the moose vital sign. The objective is:

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

Sampling Design

The Geo-Spatial Population Estimator (GSPE; Kellie and Delong 2006) technique developed by the Alaska Department of Fish and Game (ADF&G) has evolved into the standard for estimating moose abundance in Alaska and is the technique most often used by ADF&G 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 most 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 desirable parameters (rate of population change, distribution, age composition, and recruitment) are easily calculated from the data required to estimate population size.

Aerial surveys in ARCN are typically conducted during March and April when there is adequate snow cover and daylight. Eight different areas are surveyed across the five ARCN Parks. Three of the areas are considered “core” areas because of their relatively higher densities of moose and their value to local communities for subsistence resources. 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). 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 Parks will survey all of the core areas twice and each of the outer areas once (Table 2).

Data analysis will meet the main objective by estimating total abundance after each survey. Trends will be assessed based on series of such estimates over time.

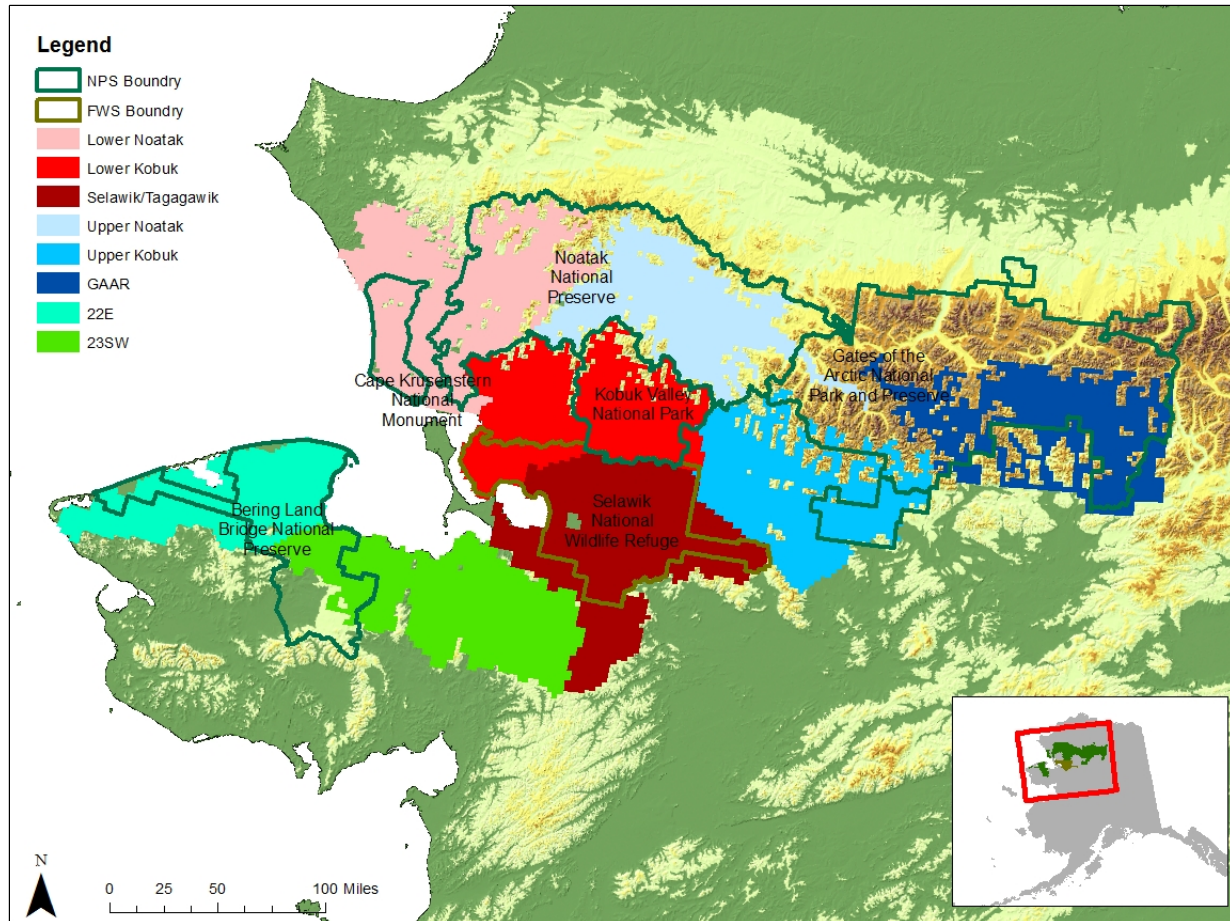


Figure 1. Moose survey areas throughout ARCN. The core areas (Lower Kobuk, Lower Noatak, and Selawik/Tagagawik) are highlighted in red and the outer areas (GAAR, Upper Kobuk, Upper Noatak, and 22E, 23SW) are highlighted in blue or green.

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

Table 2. 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)	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)	4
2006	Lower Kobuk (and eastern Squirrel)	NA
2006	Upper Kobuk (Old)	3
2006	22E	3
2007	Selawik/Tagagawik	NA
2008	Lower Noatak (and western Squirrel)	3
2009	23SW	7
2010	Upper Noatak	NA
2011	Selawik/Tagagawik	4
2011	22E	5
2012	Lower Kobuk (and eastern Squirrel)	6
2013	Lower Noatak (and western Squirrel)	5
2014	Upper Kobuk	8
2014	22E	3
2015	GAAR	11
2015	23SW	6
2016	Selawik/Tagagawik	5
2017	Lower Kobuk (and eastern Squirrel)	5
2018	Lower Noatak (and western Squirrel)	5
2019*	Upper Noatak	9
2020*	Selawik and Tag	4
2021*	Lower Kobuk (and eastern Squirrel)	4
2021*	Upper Kobuk	9
2022*	Lower Noatak (and western Squirrel)	4
2023*	22E	9
2023*	GAAR	8
2024*	23SW	9

^F - Abundance survey conducted in the fall

* - Proposed survey

Data Quality Objectives

This section is intended to demonstrate how this project generates data of known and documented quality, resulting in complete, accurate and transferable information.

Representativeness and Data Comparability. The systematic survey design of the project assures that the entire population of moose within survey area is included in the sampling frame. Therefore, there is no sample selection bias and the sample is representative of the entire population for each survey conducted under the protocol. The GSPE framework provides estimates of abundance, which can also be converted to densities. Densities are directly comparable through time and among areas. Changes in survey effort (i.e., timing, transect spacing) have no impact on data comparability because each sample will be drawn from the entire population. The approximate 4 and 8 -year sampling rotation for core and outer survey areas will be sufficient to detect large scale trends in overall populations. Due to direct dependence on moose densities and the number of units surveyed, power to detect trends cannot be conclusively determined. However, the monitoring program has already detected significant annual declines (~8% from 2008-2013 in the Lower Noatak, and ~12% annual decline (2011-2016) in the Selawik survey area (Objective 1)). These early results demonstrate the objective will be met through the application of this protocol (see SOP 3).

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.

Completeness. If surveys are unable to be completed in a scheduled year due to funding or logistical issues (such as weather and aviation issues), they will be attempted in the next year if possible to provide abundance information. Although completing surveys for all units generated for a particular year in a given area is desirable, it is not required. Due to the flexibility of the analytical framework, valid estimates can still be produced if some units are not surveyed. Another important consideration is allocation of the sampling effort. Sampling density affects the precision of the population estimate. Observations are more variable in the high stratum than the low stratum, particularly in low density moose populations such as those found in and around ARCN parks. The PI should consider allocating sampling effort between high and low stratum at a ratio near 75:25. Recent surveys have shown considerable improvements in precision over previous surveys by employing this strategy (e.g., Taras 2014, Sorum et al. 2015, Tony Gorn, ADFG Nome, *pers comm.*). While recording survey condition variables is desirable (e.g., weather, temperature, turbulence), only total group size and group composition data are absolutely required to meet Objective 1.

Measurement Quality Objectives and Performance Standards

The quality objective for each field observation and derived quantities are described in Table 3.

Table 3. Quality Objective table for moose monitoring protocol.

Measure	Quality Indicator	Quality Objective
Field Observations	Group location accuracy	+/- 50m (horizontal), no standards for vertical accuracy
	Moose group size	Pilot and observer must mutually agree on total count
	Moose group composition	Pilot and observer must mutually agree on the number of adults and calves
	Temperature	+/- 1 degree F
	Turbulence	Based on the pilot's classification of the average turbulence experienced while surveying a given transect
	Precipitation	Classified as rain, snow, or none
	Cloud cover	Classified as clear, <25%, 25-50%, 50-75%, complete
Derived quantities	Total abundance	GSPE analysis (Miller et al. 2017,, Ver Hoef 2000, 2001, 2002, Delong 2006)
	Abundance by composition class	GSPE analysis (Miller et al. 2017, Ver Hoef 2000, 2001, 2002, Delong 2006)

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