National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Moose Monitoring Protocol for the Arctic Inventory and Monitoring Network

Standard Operating Procedure (SOP) # 2 Selecting the Survey Area



ON THE COVER
Moose moving along the Noatak River during March.
NPS photograph by Kyle Joly.

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August 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science

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This report is available from the U. S. National Park Service, 4175 Geist Road, Fairbanks, Alaska 99709-3420, and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). Please cite this publication as:

Sorum, M. and K. Joly. 2018. Moose monitoring protocol for the Arctic Inventory and Monitoring Network. Standard Operating Procedure (SOP) #2 Selecting the Survey Area. National Park Service.

August 2018

Contents

Page

Overview 4

How to define the individual sample units 4

How to define the survey area based on the sample units 4

Stratification 5

Selecting the survey samples 6

Allocation of sampling effort 7

References 8

Overview

This Standard Operating Procedure explains (1) how to define the individual sample units; (2) how to select the overall survey area based on the survey units; (3) how to stratify those units into two or more strata; (4) how to select survey units to sample; and (5) allocation of sampling effort. Most of these instructions are taken directly from Gasaway et al. (1986), Ver Hoef (2000) or Kellie and Delong (2006). Kellie and Delong (2006) is a 50 page manual detailing exactly how to set up and conduct a GeoSpatial moose survey, and should be used as the primary reference. This Protocol and SOPs consist of a general overview of Kellie and Delong (2006).

How to define the individual sample units

Survey area selection starts by overlaying a portion of the predefined grid, developed by Alaska Fish and Game Department (ADFG), on the area of interest within each park. The sampling grid is a grid of rectangles defined on the north-south boundaries by even increments of 2 minutes of latitude and on the east-west boundaries by increments of 5 minutes of longitude. The average size of grid unit ranged from 5.0-5.5mi^2 (12.9-14.2km^2) across all survey areas. Using GIS, this grid is placed over USGS 1:250,000 topographic maps and sample units are removed from areas not containing moose habitat (high altitude, steep slopes, glaciers, etc.). If any unit, or portion of a unit, contains some habitat, it is included. The outer boundaries of the survey area are defined by adding or removing sample units from the grid perimeter based on previous or adjacent survey boundaries, drainages, ridgelines, or other natural features. Political boundaries are used as a general guide but every effort is made to base survey area boundaries on natural terrain features that could affect moose distribution.

How to define the survey area based on the sample units

The size of the survey areas can be up to 6,500 mi^2 (16,834 km^2) or more, but most are 4,000 mi^2 (10,360 km^2) to 5,000 mi^2 (12,950 km^2) with survey sample size usually dictated by budget. Survey areas of 4,000 mi^2 typically strive to have 150 to 200 units surveyed when estimated population abundance, but strict quotas have not been developed, and as with most statistical sampling, variability will affect meaningful sample sizes. The precision of the population estimate depends on the variability of moose density, the quality and accuracy of the stratification, as well as, the snow and weather conditions. A better approach is to monitor the precision around the point estimate daily (using GeoSpatial Population Estimator [GSPE]) software to decide how many more units to survey based on that precision.

The best way to define the survey area is to overlay the grid (as defined above) across the entire park (or area of interest) then using a select feature in GIS select the units to be included in the survey area. Units that are within the survey boundary but do not include any moose habitat can be removed. Units that include any amount of moose habitat should remain, and in general, if questionable, the unit stays in the survey. In mountainous terrain, elevation criteria can be used to exclude units. For example, all units above the elevational contour of 4000 feet (1219 m) could be excluded based on past surveys and local knowledge. This also excludes any ‘islands’ of higher mountains within the survey area. In mountainous terrain the inclusion of high altitude

areas can create a problem of incorporating too much non-moose habitat, artificially decreasing the moose density.

Sample units can be added or subtracted from the perimeter of the survey area to cover a specific area of management concern or to tailor the survey area more closely to specific geographic areas of interest. A map of the eight survey areas are provided below (Figure 1). Wherever possible the boundaries of the survey area should be guided more by terrain or habitat features of importance to moose, rather than political boundaries (the GAAR boundary is a good example). Once a survey area is defined, every effort should be made to incorporate that survey area into all future surveys to facilitate comparisons between surveys over time.

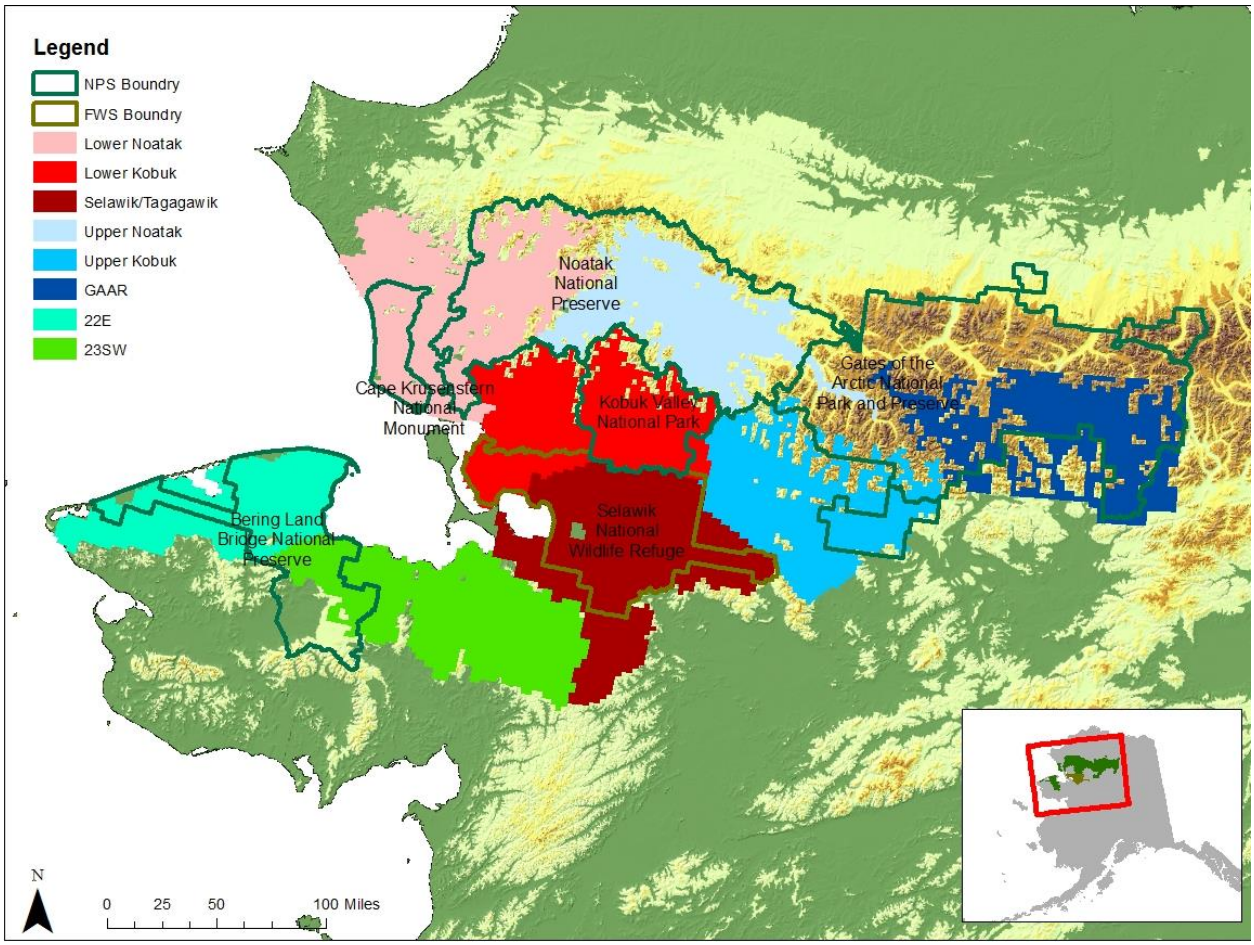


Figure 1. Moose survey areas throughout ARCN. The core areas (Lower Kobuk, Lower Noatak, and Selawik/Tagagawik) are highlighted in red and the outer areas (GAAR, Upper Kobuk, Upper Noatak, and 22E, 23SW are highlighted in blue or green.

Stratification

Once the survey area has been defined, decisions about stratifying sample units need to be made. Stratification is the sorting of survey units into strata of higher or lower numbers of moose, so that survey effort can be allocated most efficiently. The reason to stratify is to reduce the variability of moose density estimates by sampling stratum. Aerial stratifying reduces sample

variation, but can be very expensive. To aerially stratify 750 units (about 4,000 mi^2 at ARCN latitudes) would take 3 full days (24 hours) of Cessna 206 ($180/hr, government fleet rates) or Found Bushhawk time and 360 gallons of fuel, totaling about $7200 (2017 prices [$8/gal]), assuming the use of an agency aircraft). Alternatives for stratification include: a) aerial stratification (dynamic stratification), b) stratification from previous knowledge (desktop or static stratification), or c) a combination of the two.

In a dynamic stratification, an airplane (usually a Cessna 206 or Found Bushhawk) is used to fly transects through the middle of each sample unit and classify the unit based on moose seen, moose tracks, habitat, and moose seen in adjacent units. This flight should be taken just prior to the survey and can produce up to four strata of moose densities (low, medium, high, very high). Most surveys are done using two strata because it tends to be easier, and is less likely to produce classification errors. There should be four people in the airplane; the pilot, a note taker/navigator and two observers. As the plane leaves a unit, the note taker calls out the stratum of the unit and the observers and pilot concur or can question the decision. If there is disagreement (which after the first few units is unusual) the pilot can circle back through the unit in question until the decision is made. This type of stratification is the most accurate, but can change rapidly if moose move between units. To guard against some movement, units that have no moose but have moose habitat and are adjacent to high units are often classified as high as well.

Desktop or static stratification pools together all information available to stratify the area without conducting a stratification flight. This information includes moose locations from previous surveys or trend counts, locations of moose from radio telemetry studies, GIS land cover layers, personal knowledge of the area, and the knowledge of local people. Because this does not give as accurate or detailed information as a dynamic stratification there often can only be two strata (low and high). However, this stratification can be used year after year with slight modifications before each specific survey. After the same area has been dynamically stratified and surveyed repeatedly, a desktop stratification can save money which can then be put into increasing sampling intensity and tightening confidence limits. Combining some flying with a desktop stratification can be used to classify a smaller number of units that are uncertain (Kellie-Seaton et al. 2014).

Selecting the survey samples

Once the survey area has been stratified, a new random selection of survey units within each stratum is selected for surveying. The number of sample units should be selected based on desired survey accuracy, which can be estimated from previous surveys within the area. Once the number of sample units is determined, randomly select sample units for each stratum. Groups of survey units are assigned to each survey aircraft with consideration of air space between aircrafts. Up to 10 units can be placed non-randomly, as needed, to fill in geographical gaps or holes in the survey area, increasing the effectiveness of the spatial analysis (Ver Hoef 2000, Kellie and Delong 2006 page 21). The best way to determine the end of the survey is to keep close track of aircraft and fuel costs on a daily basis to determine how many days of flying are left in the budget. This should coincide with daily tracking of the size of the confidence intervals around the point estimate as well. Although the requirements for surveying low stratum units are often quickly satisfied, because these units have less variability, management or research needs

might require that more low-density units be flown, in order to get a better picture of moose distribution in low density areas. High density strata typically require more units surveyed due to higher variability.

Allocation of 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.*).

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