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Natural Resource Stewardship and Science

Moose Monitoring Protocol for the Central Alaska Network

Natural Resource Report NPS/CAKN/NRR—2012/494

ON THE COVER
Moose survey aircraft at Coal Creek Airstrip, Yukon-Charley Rivers National Preserve.
NPS photograph by Tom Meier.

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Executive Summary

This document introduces a moose monitoring protocol for the Central Alaska Network (CAKN). The network comprises Wrangell-St. Elias National Park and Preserve, Denali National Park and Preserve and Yukon-Charley Rivers National Preserve. This Protocol provides the rationale and objectives for monitoring of moose in this network, and specific instructions for implementing the monitoring program in the six Standard Operating Procedures contained in Appendix B.

The CAKN has adopted a holistic view of network ecosystems and will track the major physical drivers of ecosystem change. Moose (Alces alces) are considered good indicators of long term habitat change within network ecosystems. 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, and are harvested by the general public on NPS Preserve lands. It is the responsibility of the NPS to monitor moose populations throughout the CAKN.

People travel from all over the world to visit national parks in Alaska to view and photograph wildlife, particularly the six species of large mammals found in interior 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. The stratified random sample design developed by Gasaway et al. (1986) and modified by VerHoef (2000) will be used in CAKN moose monitoring and details are given in the form of SOPs in Appendix B of this paper. The measurable objectives are: determine changes in abundance, distribution and composition of moose in CAKN; estimate calf survival and recruitment success for moose in CAKN; and estimate annual human harvest of moose in CAKN. Surveys in each CAKN unit will cover an area of roughly 10,000 square kilometers , and occur every three years. The size and schedule is based on the generally slow speed of change in moose populations and on economic considerations.

Moose surveys are conducted aerially, and early winter is the best time. This makes use of a reasonable amount of daylight, and increases the likelihood of snow cover, which maximizes moose sightability and allows for sexing the moose as the bulls still retain their antlers. Four or five aircraft, with pilots experienced in wildlife tracking and a biologist observer in each aircraft, are needed for about five or six days to survey a 10,000 square kilometer area of interior Alaska.

Data is collected, analyzed and stored according to SOPs outlined in this paper. As the program evolves, changes to text and SOPs will be documented.

Acknowledgments

The authors would like to acknowledge the biologists and statisticians with the Alaska Department of Fish and Game, who have developed and tested methods of surveying moose in interior Alaska, along with methods of analyzing the results of moose surveys, for many years. We would also like to 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.

I. Background and Objectives

This document is the Moose Monitoring Protocol for the Central Alaska Network (CAKN). The CAKN monitoring network comprises Wrangell-St. Elias National Park and Preserve (WRST), Denali National Park and Preserve (DENA) and Yukon-Charley Rivers National Preserve (YUCH). The text of the paper explains the rationale for moose monitoring and sets forth the specific objectives to be achieved. This provides context for the Standard Operating Procedures (SOPs) contained in Appendix B. The SOPs provide the details on how to carry out the protocol.

Issues Being Addressed and Rationale for Monitoring Moose Populations

The CAKN has adopted a holistic view of network ecosystems and will track the major physical drivers of ecosystem change and responses of the two major components of the biota: plants and animals. Thus, the CAKN has identified *Fauna Distribution and Abundance* as one of its top three Vital Signs. Monitoring of animal abundance and distribution was ranked third among all potential Vital Signs evaluated by the CAKN. In general, the CAKN wants to know where fauna are distributed across the landscape and to track changes in both their distribution and abundance. The *Fauna Distribution and Abundance* Vital Sign comprises monitoring efforts for a suite of vertebrate species spanning the significant elevation gradient found in CAKN parks, and includes species of specific interest within each park. Moose (*Alces alces*) are one such species for the CAKN in part because moose are an important part of the ecosystem in each network park. Moose are considered good indicators of long term habitat change within park ecosystems because they require large quantities of resources from their habitat year round, and populations have the potential to respond dramatically 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 one of six keystone large mammal species in interior Alaska which are of great importance ecologically as well as from a management perspective. In short, moose are important to people from both consumptive and non-consumptive viewpoints.

Moose are also one of the primary species in a far reaching ecological question: Why do ungulate populations change in Alaska and what role does wolf and bear predation play in that change? 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 chemistry or water quality could all have potentially dramatic affects on moose forage quality (e.g. secondary plant compounds) and quantity, which in turn could cause dramatic changes in moose population size or distribution. These other habitat variables are often easily dismissed by many in favor of predator control to increase ungulate populations. As part of an integrated Vital Signs Monitoring Program, CAKN will monitor many of the habitat variables that can potentially affect a moose population, and will also monitor wolf and bear populations in some parks. All of these variables will be monitored over the long term in the same places, something unprecedented in Alaska. Although this view of CAKN's habitat change model will not produce data to allow evaluation of cause and effect, it will produce data to measure correlations between variables that in turn could leverage more focused research to look for specific forms of cause and effect. In this way, CAKN has the potential to lend great insight into one of the most contentious ecological questions in Alaska.

Moose, along with many other natural resources, may be harvested by people throughout most of CAKN. Indeed the only place where moose are completely protected from human harvest is within the old (pre 1980) boundary of Denali National Park, formerly Mount Mckinley National Park. 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 park units created by the Alaska National Interest Lands Conservation Act of 1980 (ANILCA), including the three CAKN units (DENA, WRST, and YUCH). ANILCA mandates that harvest of fish and wildlife be consistent with the conservation of natural and healthy populations within a national park or national monument, and that harvest be consistent with the conservation of healthy populations within national preserves. Definitions of "healthy" and "natural and healthy" have been drafted but not finalized, but in general are defined as stable and continuing populations that are not driven by human harvest or human-caused change (NPS 1998). Over the past two decades, population monitoring on federal lands by the Alaska Department of Fish and Game (ADF&G) has consistently decreased due to budgetary constraints, and monitoring of many harvested species on federal lands has become the responsibility of the individual federal land management agencies. This has become the case with moose populations on most NPS lands in Alaska. In short, it has become the responsibility of the NPS to monitor moose populations throughout CAKN.

Good estimates of population size, rate of change, composition, 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 CAKN.

Information gained from monitoring moose in CAKN will be fully integrated with other vital signs monitored in CAKN. The vital sign of vegetation structure and composition will provide data on willow and other forage plants that moose depend on. Weather data, predominately snow depths, can be used as an indicator of winter severity so that weather change can be compared to changes in the moose population. Fire history will also be documented and monitored, and correlations can be made between fire history and severity and changes in the distribution and population size of moose in CAKN. Moose mortality is a major population parameter not covered by this protocol but will be covered in part by monitoring other proposed vital signs such as human harvest, and the abundance and distribution of wolves and bears. Wolf and bear monitoring will record wolf and bear-killed moose when they are found, and by using previously published predation rates and applying those to current estimates of wolf and bear populations, estimates of the number of moose killed can be made. Correlations will be made between trends in moose and predator populations lending great insight into areas for more focused research.

The non-consumptive opportunities that moose provide for viewing and photography in CAKN are probably unequaled anywhere else in the world (Van Ballenberghe 2004). People travel from all over the world to visit national parks in Alaska (primarily DENA) and one of the primary goals of many visitors is viewing and photography of wildlife, particularly the six species of large mammals found in interior Alaska. The non-consumptive value of wildlife is difficult to estimate when one realizes that the existence of such a place as Alaska, where ecosystems are still pristine enough to support the full complement of wildlife species in a completely wild state, is of great importance to many people, even if they never see them. It is the responsibility of the NPS to ensure that opportunities like these remain unimpaired for future generations. The Vital Signs Monitoring process, of which CAKN is a part, is one tool NPS is using to fulfill that responsibility.

Measurable Objectives

There are three primary objectives for the monitoring described in this protocol:

1. Determine changes in abundance, distribution and composition of moose in CAKN
2. Estimate calf survival and recruitment success for moose in CAKN
3. Estimate annual human harvest of moose in CAKN

Historical Development of Moose Monitoring in Alaska

Various survey techniques have been used for estimating moose populations in North America, including counts of moose pellet groups (Neff 1968, Timmermann 1974, Franzmann and Arneson 1976), aerial quadrate 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 (ADF&G) began developing a modification (the Geo-Spatial Technique) to the basic approach of stratified random sampling that involves the use of spatial statistics (finite population block kriging), and has three main advantages over standard stratified random sampling: it is usually more precise; the size of the overall survey area is more flexible; and it allows nonrandom sampling designs which give biologists conducting the survey much greater flexibility. The technique defines the individual sample units on a grid of square sample units based on minutes of latitude and longitude, rather than landmarks discernable from the air (rivers, creeks ridgelines etc.) and uses GPS devices in the aircraft to navigate the borders of the units (Ver Hoef 2001, 2002).

II. Sampling Design

Rationale for Selecting this Sampling Design Over Others

As mentioned above, several different techniques have been used to measure moose abundance in Alaska. One technique (stratified random sampling) developed by the ADF&G has evolved into the 'industry standard' for measuring moose abundance in Alaska and is the only technique use by ADF&G and most federal agencies in interior Alaska and the Yukon. The authors of this protocol have used this technique since 1987 (Meier et al. 1987) on NPS lands in Alaska.

The stratified random sample design developed by Gasaway et al. (1986) started by making modifications to designs from Siniff and Skoog (1964) and Evens et al. (1966). This method was chosen over others because it 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 to mountainous terrain; (4) It has analytical software available for consistent, error free calculations; (5) It is affordable (Gasaway et al. 1986). The history of wide use and acceptance over nearly 20 years indicates the protocol described here meets these five criteria. 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

The total survey area in each of the three CAKN parks has been defined based on a balance of ecological, economic and integration considerations. Economic considerations have limited the overall size of the survey area to 10,000 km^2 within each park, and each park may choose to add funding to survey additional areas of specific management concern that are not covered by the vital signs monitoring (for example the Cantwell and Yentna areas on the south side of DENA). Moose survey areas were placed in each park in order to co-locate with as many Vital Signs Monitoring sites as possible, yet cover areas in each park most important to moose. These areas were also influenced by past surveys and ecoregion boundaries. These survey areas are not large enough to make park-wide inferences, but are large enough to monitor large proportions of each park. The survey areas will exclude areas not thought to contain possible moose habitat. For example, in interior Alaska, 20 years of past moose survey experience has shown that few moose are found above 4000 feet in elevation in November. These areas and other non-habitat areas (permanent rock and ice) have been removed from the survey area.

Survey area selection starts by overlaying a portion of the predefined grid on the area of interest within each park. The sampling grid is fully defined in SOP#2 (Appendix B), but 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. 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, might contain 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.

Population Being Monitored

Moose surveys should be conducted in early winter (mid October to mid December). Aerial moose surveys require good snow cover to maximize moose sightability and a reasonable amount of daylight to make aircraft use economical. In interior Alaska, adequate snow cover for an early winter survey is fairly reliable, but does fail. When snow conditions fail it is tempting to conduct the surveys in spring. However there are two distinct advantages to conducting the surveys in early winter; the bulls will not have lost their antlers so the sex composition data are not lost, and moose sightability is greater in early winter because moose are in larger groups and prefer low vegetation and open canopy habitats (Lynch 1975, Peek et al. 1974). In interior Alaska, short daylight hours, particularly in late November to early December, can cause a survey to become uneconomical, depending on the distance of survey units from the base of operation. The later in the year that surveys are done, the more expensive they become.

Moose in some populations are known to move long distances in fall and spring. The fall movements are typically complete by mid to late October so are not a factor regarding most surveys (Rod Boertje, ADF&G Fairbanks, personal communication, Gasaway et. al. 1983, Ballard et. al. 1991, Hundertmark 1998). The population being sampled includes moose that are within the survey area boundary during the time that the survey is being conducted, usually November. Whether or not November population estimates are representative of the September harvested population in each park remains in question.

Sampling Frequency and Replication

Due to budget considerations, it is not reasonable to conduct moose surveys annually in each of the three parks in CAKN. Furthermore, moose populations usually will change slowly enough that a population estimate once every three years will be adequate to detect a change in abundance, distribution or composition. One survey will be conducted annually by CAKN, rotating through the three parks, producing a population estimate in each park once every three years.

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. At this writing a Student’s *t*-test will be used to determine whether a statistically significant difference exists between any 2 survey estimates. More sophisticated methods of detecting trends in population change could be developed using Maximum Likelihood Theory (J. VerHoef and E. DeBevec, pers. comm.). Composition data will be used for tracking trends in calf survival and recruitment (yearlings) as well as monitoring trends in the bull to cow ratio. Correlations can then be made between any measured trends in habitat change and trends in the moose population.

III Field Methods

Survey Preparations and Schedule

Timing of moose surveys revolves around three primary factors: snow conditions, antler loss, and daylight, which generally restricts the area that may be covered in a day. Prior to each survey, even as early as August, the Principal Investigator (PI) should line up aircraft and pilots for the survey. This may seem early, but the more experienced pilots are scheduled for moose surveys far in advance and the more experienced the pilots the better and safer the survey (See SOP #1 aircraft and pilot requirements in Appendix B). 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. The biologists and all observers should review this entire protocol, including all of the SOPs, and review 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". Enough maps need to be made so that there are two full sets of maps 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 Moose Survey Data Form (Appendix A) should be made. Two copies per surveyed sample unit is plenty for a low density population.

Right before the survey is flown, the survey area needs to be stratified 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"); 3) A variation of the office or 'desktop' stratification is to use prior knowledge of moose distribution to assume that a large part of the total survey area is in one (usually low density) stratum, thereby eliminating the need to stratify this part of the survey area with an aircraft. The assumption is that there is little variation in moose abundance between sample units in that area.

Prior to any aerial stratification or the survey itself, adequate snow cover 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 for 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 Ver Hoef's Geo-Spatial Method does allow the survey to be spread out in time and is therefore more forgiving 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 six and 12 units per day. With four or five aircraft flying on the same survey, it is not uncommon to complete 30 or 40 units per day. On larger survey areas, 200 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 one or two days should be factored in to account for bad weather when no surveying can take place, possibly more in some areas. Unfortunately, October and November often have some of the worst aviation weather for interior Alaska.

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. When it comes to actually flying the survey, the primary changes from Gasaway et al. (1986) developed by Ver Hoef (2001, 2002) involve the smaller, roughly square sample units based on latitude – longitude coordinates that are flown more intensively (about eight minutes per square mile vs. four or five minutes per square mile) with the assumption of 100% moose sightability. ADF&G has developed some preliminary sightability correction factors based on habitat types and tests with radiocollared moose (Boertje and Kellie 2007). For YUCH this has worked out to 1.2, or adding 20% more moose to those observed.

The details in SOP #3 should be followed, but the main points to keep in mind are to split the survey area into practical areas in order to separate aircraft, to have each pilot/observer team act independently of the Project Leader for making decisions on which units to fall back to if weather prevents flying assigned units, to have all aircraft communicate on a prearranged radio frequency, and to arrange that if a plane needs to move into another aircraft's area due to weather, they must contact that aircraft and work out which units each will fly. 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. Units with tall or thick spruce trees will require more survey time than units with more open vegetation. Units that are wide open with little or no vegetation can be flown very quickly. 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, can be recorded from the aircraft's GPS or waypointed by the observer.

Each evening, all data sheets from each plane are collected and the data entered into two specific formats. One format is an ASCII text file that is then read into MOOSEPOP, a computer program, from which preliminary point estimates, sex-age ratios, and confidence intervals can be calculated (Reed 1989). The other format is intended for use with the software for geo-spatial analysis, GSPE software (Ver Hoef 2000, Delong 2006).

Estimating Annual Human Harvest of Moose in CAKN

Consumptive use of fauna within CAKN will be covered by a separate Vital Sign which will include moose harvest. These data will summarize harvest data from ADF&G and the U. S. Fish and Wildlife Service Office of Subsistence Management, in order to report the numbers and sex of moose reported as harvested each year in the areas of interest within each of the three CAKN parks.

IV. Data Management

Overview of Database Design

Two databases have already been designed. Each database is specifically designed as an input data file for analytical software. The first database was designed by Gasaway et al. (1986) as the input file for MOOSEPOP (Reed 1989), which makes the calculations for the stratified random sampling analysis used in past years. This software may also be used to produce preliminary results from geospatial moose surveys. The second database was designed by Ver Hoef (2001) as the input file for GSPE software, which performs the geo-spatial analysis. It is not necessary to use MOOSEPOP, however MOOSEPOP is available on disc and can be used on any DOS or Windows-based computer in a field camp situation. GSPE software is currently only available through ADF&G's website. If internet access is not available at the base of operation for the survey, MOOSEPOP can be used each evening to track the progress of the survey. The data would then be run through GSPE software when back in the office to calculate the final estimates. Keeping track of the progress of the point estimate and confidence interval is a particularly good idea when nearing the end of the survey, in order to make decisions regarding optimal allocation of funds to best reduce variability. MOOSEPOP has a specific routine in it just for this purpose. If internet access is available, GSPE software can be used instead of MOOSEPOP.

In 1995, Bruce Dale (ADF&G, Palmer) modified MOOSEPOP to accept larger numbers of sample units per stratum and coined it MODPOP. MOOSEPOP is limited to 80 units per stratum where MODPOP will accept over 200 units per stratum. With the large number of smaller survey units now being surveyed under the Geo-Spatial Technique, MODPOP should be used in place of MOOSEPOP.

The design of both databases 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. An example of each file is available in Appendix C. For MOOSEPOP, dBase was the data entry tool of choice and the file was exported to an ASCII text file for input into MOOSEPOP. Now that dBase is not widely available, data entry for MOOSEPOP is made into any text editor (MS WORD, NOTEPAD, etc). GSPE software uses EXCEL, and is available through ADF&G's web site at http://winfonet.alaska.gov.

Data Entry, Verification and Editing

Data entry into either the GSPE software or MOOSEPOP formats is performed each evening after the data sheets are gathered from each aircraft. A GSPE software file can be made from a MOOSEPOP file fairly easily by rearranging and adding a few fields. The data are basically identical with the addition of the latitude and longitude coordinates of the center of each sample unit.

Data verification (summing the total moose seen in a unit and the totals for each age and sex class) is done in the airplane on the data sheet and again when the data are entered into the database. The data sheet (Appendix A) is designed to keep track of the number and composition of moose seen and the location of moose groups. A separate data sheet is used for each sample unit. The data sheet has a total column for each group of moose seen and a total row at the bottom to sum each sex and age category/column. This design allows error checking by verifying that the grand sum of columns is the same as the grand sum of rows. If the two totals are not the same, a data entry or addition error has been made. The addition errors are not much of a problem because the data analysis software does this same addition, but the calculation of total moose seen in a unit helps ensure that the data entry is correct. When errors are found, they are corrected on the data sheets as well as in the database.

Metadata procedures - see SOP#4 Data Management
Data archival procedures – see SOP#4 Data Management

V. Analysis and Reporting

See SOP#5 Data Analysis and Reporting

VI. Personnel Requirements and Training

Roles and Responsibilities

A designated wildlife biologist from each park will be the lead for implementing this monitoring protocol in their individual park. CAKN biologists participate as observers, assisted by other park staff as needed. Data management is the shared responsibility of the biologist from each park and the network data manager.

Typically, the individual park biologist 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 ultimately responsible to see that adequate Quality Assurance/Quality Control (QA/QC) procedures are built into the database management system and 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 only 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 promising 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 together with the pilot and send them out with the most experienced pilot available. At the end of the first day, the pilot can then give the project biologist a critique of the observer's abilities. Luckily, flying as an observer on a moose survey is not that difficult and, with some coaching, can be accomplished by most people with some science background.

VII. Operational Requirements

Annual Workload and Field Schedule

Moose surveys will begin no sooner than mid-October and extend no later than mid- December. If the survey has not been completed by mid-December, a decision will need to be made as to whether a spring survey should be attempted or the survey postponed until the following year. Sex and age ratios are unobtainable and moose sightability is lower in spring surveys. Snow and weather conditions will dictate when the survey can be completed. Approximately five to seven days are required to complete a moose survey of approximately 10,000 km^2 with four aircraft. It is proposed to conduct one survey in each of the three CAKN parks once every three years in rotation.

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. 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 Coal Creek in YUCH that are without electricity. Enough fuel will need to be lined up in advance and fuel transfer systems set up and tested in advance. Remote fuel caches need to be supplied before it snows (Chisana in WRST, Kantishna in DENA). 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 survey aircraft 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. 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.

Budget

Personnel expenses for field work are assumed to be covered by park base money from the three CAKN parks. Over 95% of the cost for conducting a moose survey is aircraft rental and fuel. The amounts listed in Table 1 are the estimated costs for conducting a moose survey over a 10,000 km^2 survey area. Fuel costs include delivery.

Table 1. Estimated costs by park for conducting a moose survey over a 10,000 km^2 survey area in each park, assuming no stratification flights. Aerial stratification is likely to add $6,000 to $10,000 to the cost.

Estimated Costs	DENA	WRST	YUCH
Food (housing provided by host park)	1,000	1,000	1,000
Contract Aircraft 3 for 5 days (120 hrs @ 220/hr)	26,000	26,000	26,000
DOI agency Aircraft 1 for 5 days (40hrs @ 125/hr)	5,000	5,000	5,000
Fuel 1600 gallons @ $5.00/gal	8,000	8,000	8,000
Total	40,000	40,000	40,000

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 as an Appendix 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 Survey Data Form

Page ___ of ___ Revised: 12/15/04

SEARCH IDENTIFICATION		SEARCH EFFORT	SEARCH TIMES (in minutes)
Date: ________	SU #: __________		
GMU: ________		~8 min/mi^2 (depends on terrain)	Stop@ __________
Location: ____________________			
Observer: ____________________			Start@ __________
Pilot: ____________________		Stratum: ________	
Aircraft Type: ________	Temp (F) __________	Area (mi^2): ________	Elapsed __________

OVERALL SURVEY RATING: o Excellent o Good o Fair o Poor

SEARCH CONDITIONS

SNOW AGE	SNOW COVER	PREDOMINANT HABITAT TYPE IN SU
o 1. Fresh	o 1. Complete	o 1. Open lower elevation, predom shrub, riparian, or wetland
o 2. < 1 week	o 2. Some Low veg Showing	o 2. Mixed Open Forest with some shrub understory
o 3. >1 week	o 3. Bare Ground Showing	o 3. Dense Spruce Forest
LIGHT TYPE	LIGHT INTENSITY	o 4. Dense Deciduous Forest Birch, Aspen, etc. Few Shrubs
o 1. Bright	o 1. High	o 5. Subalpine Shrub
o 2. Flat	o 2. Medium	o 6. Burn
	o 3. Low	o 7. Open tussock tundra with forested 'stringers'
		o 8 Other (describe):

CHECK ADDITIONAL CONDITIONS THAT MAY HAVE AFFECTED THE QUALITY OF THE SEARCH

o Classification Errors	o Inadequate Snow Cover	o Poor Light	o Low Clouds or Fog
o Uncooperative Pilot	o Inexperienced Pilot	o Inexperienced Observer	o Poor Visibility/Snow on Trees
o Inadequate Search Effort	o Movement In/Out Of Intensive	o Large Number of Moose in Unit (>25)	o Problems finding SU Boundaries
o Short on Fuel	o Movement In/Out of SU		
o Windy/Turbulent	o Improper Aircraft	o Observer Airsick	o Observer Sleeping
o Other (Explain):			

	Bulls			Cows				MISC			
Group No.	Yrlg	Med	Lrg	Cow w/0	Cow w/1	Cow w/2	Cow w/3	Lone Calf	Unk	Total Moose	Remarks/Waypoint/Lat-Lon
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											
9.											
10.											
11.											
12.											
13.											

Survey Summary (Do not add calves to cows in column totals)

1-13											**Total Number of Moose**:
14-45											
Total											

Moose Survey Data Form, continued

Group No.	Bulls			Cows				MISC		Total Moose	Remarks/Waypoint/Lat-Lon
	Yrlg	Med	Lrg	Cow w/0	Cow w/1	Cow w/2	Cow w/3	Lone Calf	Unk		
14.											
15.											
16.											
17.											
18.											
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35.											
36.											
37.											
38.											
39.											
40.											
41.											
42.											
43.											
44.											
45.											

Survey Summary Subtotal (Do not add calves to cows in column totals)											
14-45											

Appendix B. Standard Operating Procedures (SOPs)

Standard Operating Procedure (SOP) # 1 Survey Preparation and Timing

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

Standard Operating Procedure (SOP) # 3 Survey Methods and Flight Patterns

Standard Operating Procedure (SOP) # 4 Data Management

Standard Operating Procedure (SOP) # 5 Data Analysis and Reporting

Standard Operating Procedure (SOP) # 6 Revising the Protocol

Standard Operating Procedure (SOP) # 1 Survey Preparation and Timing

Version 1.0 (August 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Overview

This SOP describes various tasks needed to prepare for a moose survey, and some guidance on the timing of the surveys.

General Summary

Prior to each survey, even as early as August, the Project Leader should line up aircraft and pilots for the survey. This may seem early, but the more experienced pilots are scheduled for moose surveys far in advance, and the more experienced the pilots the better and safer the survey. 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. The biologists and all observers should review the entire protocol, including all of the SOPs, and review Gasaway et al. (1986) and Kellie and DeLong (2006). Enough maps need to be made so that there are two full sets of maps 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 Moose Survey Data Form (see Appendix A) should be made. A supply of 250 copies is more than enough for most populations and allows plenty of extras to go around.

I. Review and Survey Schedule

Procedures

1. Review Gasaway et al. (1986), Ver Hoef (2000, 2001, 2002), and Kellie and DeLong (2006), and Delong (2006). These documents go into great detail on how to conduct a moose survey. This protocol attempts to summarize these documents in the required format. If any questions arise they can likely be answered by referencing these documents.

2. All reports from previous surveys, or other studies of moose covering the survey area should be reviewed by the PIs.

3. As early as possible, establish the budget and a preliminary idea of where and how large the area to be surveyed is (about 10,000 km^2 in each of the three CAKN parks, defined in SOP #2, "Selecting the Survey Area"). This will allow calculation of the number of aircraft to schedule and how much fuel to have available. Primary moose monitoring areas for each park should be carefully chosen to remain unchanged from year to year if at all possible.

4. Determine the number of aircraft needed. Generally the more the better, but four or five are typically used for most surveys. The more planes there are, the faster the survey can be finished, which is an advantage with the frequently short windows of good flying weather.

5. Calculate and order enough fuel for the survey, not forgetting the fuel requirements for stratification. Most survey aircraft burn eight or nine gallons per hour so using 10 gallons per hour as an average is safe. Plan on each survey aircraft flying eight hours per day even though it will probably be less. Stratification aircraft are typically a Cessna 185 or 206 and they typically burn about 14 gallons per hour, but a conservative estimate would be 15 gallons per hour. Three 8 hour days of stratification typically will cover a 10,000 km^2 sized area. Using these criteria will create a small surplus of fuel, which is better than running out, and the extra fuel is always useable for unforeseen contingencies or other work. Once the fuel is gone, the survey is over if more cannot be delivered. When the survey is based at Coal Creek in YUCH or any other remote fueling site (Kantishna in DENA, Chisana in WRST), this detail is particularly important as fuel becomes extremely expensive (two to three times as much per gallon) to be flown in on an airstrip where ski-equipped aircraft are required. As an example, using the above criteria and assuming four survey aircraft for five days and one stratification plane for three days, total fuel needs add up to 1960 gallons of fuel.

6. Contact prospective pilots as soon as possible and try to give them some estimate of survey dates, even though the schedule is likely change due to weather and snow conditions or scheduling of other agency surveys. At the same time, be sure to line up observers for each aircraft and have one or two alternates in case someone can't make it

or you pick up additional aircraft at the last minute. Moose surveys in Alaska are becoming more common, and often many biologists are trying to do them at the same time. If aircraft are not lined up ahead of time it is likely that none will be available when the survey should be completed, or the most experienced pilots will be unavailable. Using experienced pilots cannot be overemphasized, not just for safety reasons but for data quality and overall success of the survey. Less-experienced pilots can be used, particularly to train new pilots so more are available in the future, but the majority of pilots on a survey should have considerable past experience. The most experienced biologist/observers should be matched up with the least experienced pilots and vice versa. Moose surveys can be dangerous because of long hours of low, slow flying, and indeed aerial wildlife survey work in general is considered one of the more dangerous occupations, particularly in Alaska (Sasse 2003). As a result, safety should be thoroughly addressed, and cannot be overemphasized. One of the best and most effective safety measures a biologist can make is to use the most experienced pilots available, regardless of cost or agency affiliation. When it comes to aircraft safety in wildlife survey work, there is no replacement for experience with that type of flying. Experience with routine, point to point flying doesn't replace experience with aerial survey work. .

7. Schedule the survey for a time when the area will most likely have good snow cover. For example, DENA will likely have adequate snow cover earlier in the year than YUCH.

8. Surveys should be scheduled for the time of year when most moose surveys were conducted in that area in the past. If unusually early (Late September, early October) snowfall occurs in the survey area, it is tempting to fly the survey then, but this may confound making comparisons to past surveys, because of moose migration patterns. It is better to wait and conduct the survey when most past surveys were completed.

9. If adequate snow cover is lacking (see discussion of adequate snow cover below), the survey will need to be postponed until enough snow falls or until antler loss and short daylight preclude conducting the survey at all (usually mid December). At this point, a decision will need to be made to conduct a spring survey or wait until the following fall.

10. All required safety equipment (helmets, cold weather gear, park radios and satellite phones) should be assembled well in advance. A Project Aviation Safety Plan needs to be written and approved by the park superintendent. Daily "Go/No Go" determinations are made for each flight immediately before flight commences, and flight plan and flight following procedures will need to be met for each aircraft. These requirements are often fulfilled by using Denali Dispatch center for flight following

II. Organizing Supplies and Equipment

Procedures

1. Maps of the survey area should be prepared using a GIS such as ArcGIS. The grid of sample units (explained in SOP #2) is overlaid on 1:250,000 scale topographic maps. A good template to follow is to have the grid and unit numbers on the front/map side of the map and the grid, unit number and coordinates of the southeast corner on the back (without a map as a background) this makes the map less cluttered and more readable. Laminating the maps

makes them far more durable while in use in the aircraft. An alternative is to produce maps of the entire survey area with a plotter, placing the unit numbers and coordinates in the southeast corner of each unit. Such maps can then be folded and marked as needed by individual observers and pilots. If the area has been stratified, the sample units can be color coded as to which stratum they are in and then further colored or shaded to reflect those units that have been randomly selected to be surveyed.

2. The survey form (see Appendix A) should be printed out double-sided and photocopied. Numerous copies of the survey data form should be made, with 250 copies probably being adequate for most surveys. Other potential data forms that can prove useful at times are found in Gasaway et al. (1986).

3. A simple spreadsheet should be developed to track daily costs of aircraft rental. This becomes particularly useful near the end of the survey. Don't forget fuel costs, ferry time and per diem for the pilots. Buying group food can save a lot in pilot per diem costs.

4. A list of all sample units in numeric order should be made and enough copies made so each aircraft will have a copy as well as a few extras.

5. Input data files for MOOSEPOP (MODPOP) should be set up and tested with example files or previous survey files for testing the input data file (Reed 1989).

III. Snow Conditions and Antler Loss

Snow conditions have a major influence on moose sightability. The PIs of the survey should ensure that satisfactory snow conditions exist throughout the survey area. Gasaway et al. (1986, pages 19-23) has a thorough description of snow conditions that will only be summarized here. Gasaway et al. (1986) breaks up the evaluation of snow conditions into two parts, snow age and snow cover. The best snow conditions are a complete snow cover of 6 – 12 inches with at least 3 inches that is less than a week old with little or no wind scouring. However, surveys can be completed with less than perfect snow conditions, the minimum being defined as complete snow cover that is two or more weeks old, or snow of moderate age (between one and two weeks old) with some low vegetation showing, or fresh snow (at least 3 inches less than a week old) with some low vegetation showing. These are just subjective guidelines and the decision to conduct the survey will fall to the PIs and their evaluation of the snow conditions in the survey area. This may require a reconnaissance flight if no other way to determine snow cover exists. Air taxi operators and local residents are possible sources for information regarding snow fall and snow cover. Also, data from CAKN's climate stations or MODIS images will be available to help assess snow conditions in the survey area.

By mid- to late November, the larger bulls can begin to lose their antlers, but usually only one or two one-antlered bulls are seen in mid-November surveys (Gasaway et al. 1986, Burch 1999, 2003). Younger, smaller-antlered bulls keep their antlers much later. As winter progresses and surveys are conducted from late November into mid December, antler loss can start to affect sex ratios as the number of large bulls that have lost both antlers increases and these animals are misidentified as cows.

IV. References

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

Version 1.0 (August 2011)

Revision History Log:

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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; and (3) how to stratify those units into two or more strata. 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).

I. How to define the individual sample units

The survey area will be made up of a grid of individual survey units (see maps at the end of this SOP). This grid of rectangles is 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. At 65 degrees latitude these sample units are approximately 5.5 mi^2 or 14.2 km^2. This grid can be developed in a GIS such as ArcGIS and overlaid on a 1:250,000 scale topographic map of the area to be surveyed.

II. How to define the survey area based on the sample units

The size of the survey area can be up to 13,000 km^2 or more, but most are 5000 km^2 to 10,000 km^2 with survey size usually dictated by budget. Survey areas of 10,000 km^2 typically strive to have 150 to 200 units surveyed, but strict quotas have not been developed, and as with most statistical sampling, more is usually better than less. 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, or MOOSEPOP if no internet connection is available) and 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 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. This is an area where more protocol development may need to take place. One possibility would be to go back to non-rectangular sample units based on terrain features (as described in Gasaway et al. 1986), but only in the areas of the survey with high elevation or steep terrain. Coordinate-based units would be used for the rest of the area. This combination may, however, not be compatible with the spatial analysis of GSPE (formerly known as SMOOSE).

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. The maps at the end of this SOP show the survey areas defined for YUCH and DENA. The map of WRST is an approximation and needs to be specifically defined, but shows what approximately 10,000 square kilometers looks like overlaid on the WRST boundary. 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 YUCH map 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.

III. 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 groups of units that are expected to contain 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. In some situations it is not reasonable to stratify. In general, aerial stratifying helps a lot, but can be very expensive and can cut into the available window of favorable weather conditions. To aerially stratify 700 units (about 10,000 km^2 at CAKN latitudes) would take 3 full days (24 hours) of Cessna 185 or Found Bushhawk time and 360 gallons of fuel, totaling about $6200 (2011 prices, 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 185 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, locations of wolf-killed moose, 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.

IV. 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. Groups of survey units are assigned to each survey aircraft. Sample units should be surveyed in as close to random order as possible with efficiency in mind. If there is no doubt, for example, that at least the top 50 units in a stratum will need to be flown (as is likely to be the case), then those units can all be flown immediately, without regard to their random order. As the end of the survey approaches, any units that have been missed in the random order become a high priority. 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. MOOSEPOP has an optimum allocation routine that can be helpful in deciding how many units of each stratum will best reduce the variance (Reed 1989). Although the requirements for surveying low stratum units are often quickly satisfied, because these units contribute little to the overall population estimate, 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.

V. References

Gasaway, W. C., S. D. Dubois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Papers, University of Alaska. No. 22. 108pp.

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Reed, D. J. 1989. Moosepop program documentation and instructions. Alaska Department of Fish and Game. 15pp.

Ver Hoef, J. M. 2000. SMOOSE: A spatial moose survey estimation method. Alaska Department of Fish and Game report, Fairbanks, Alaska. 4pp.

Figures 1-3. Maps of survey areas in WRST, DENA and YUCH.

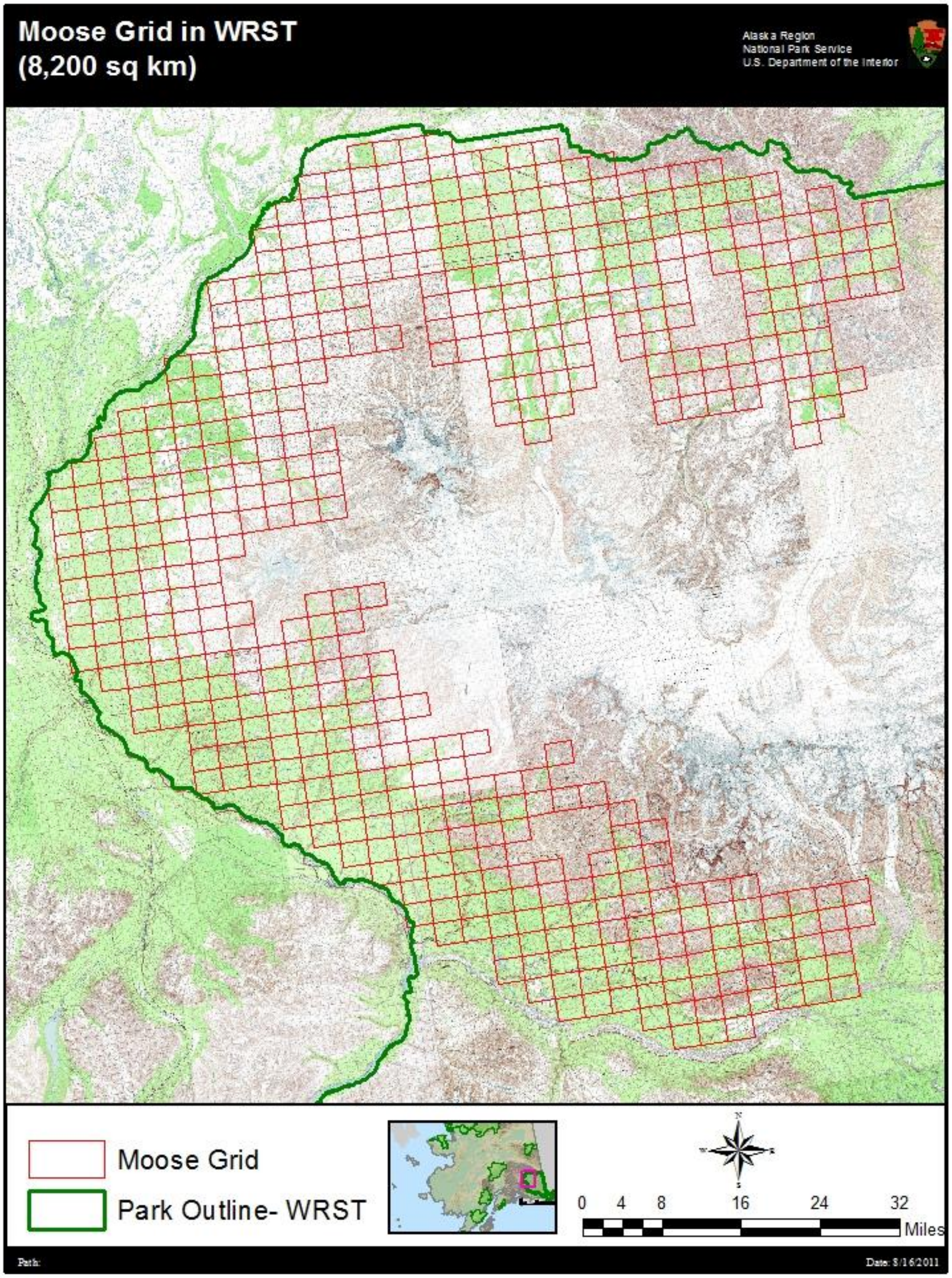


Figure 1: Hypothetical moose survey grid (8,200 km^2) for WRST.

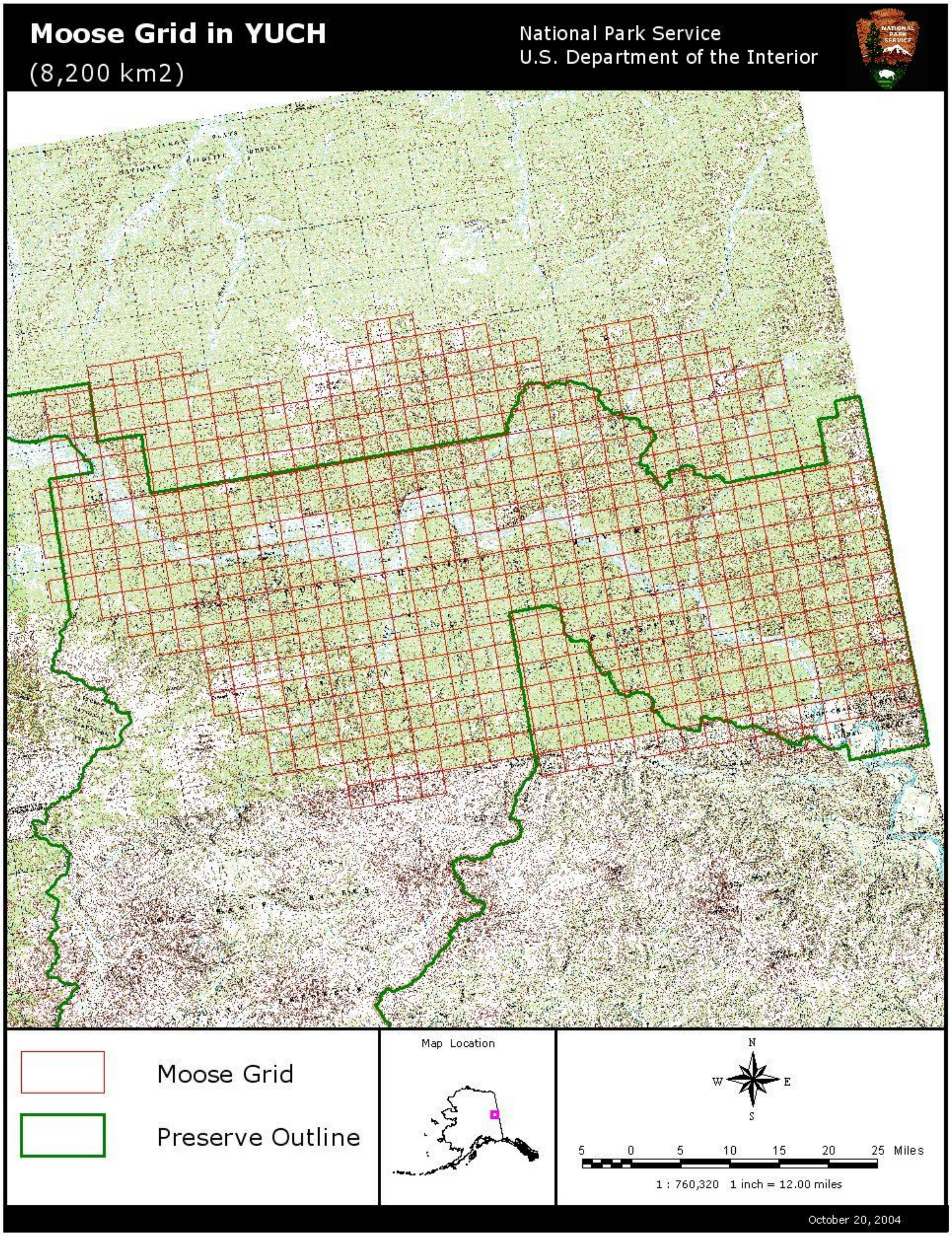


Figure 2: Moose survey grid (8,200 km^2) for YUCH, surveyed in 1987, 1994 (partial), 1997, 1999, 2003, 2006, and 2009.

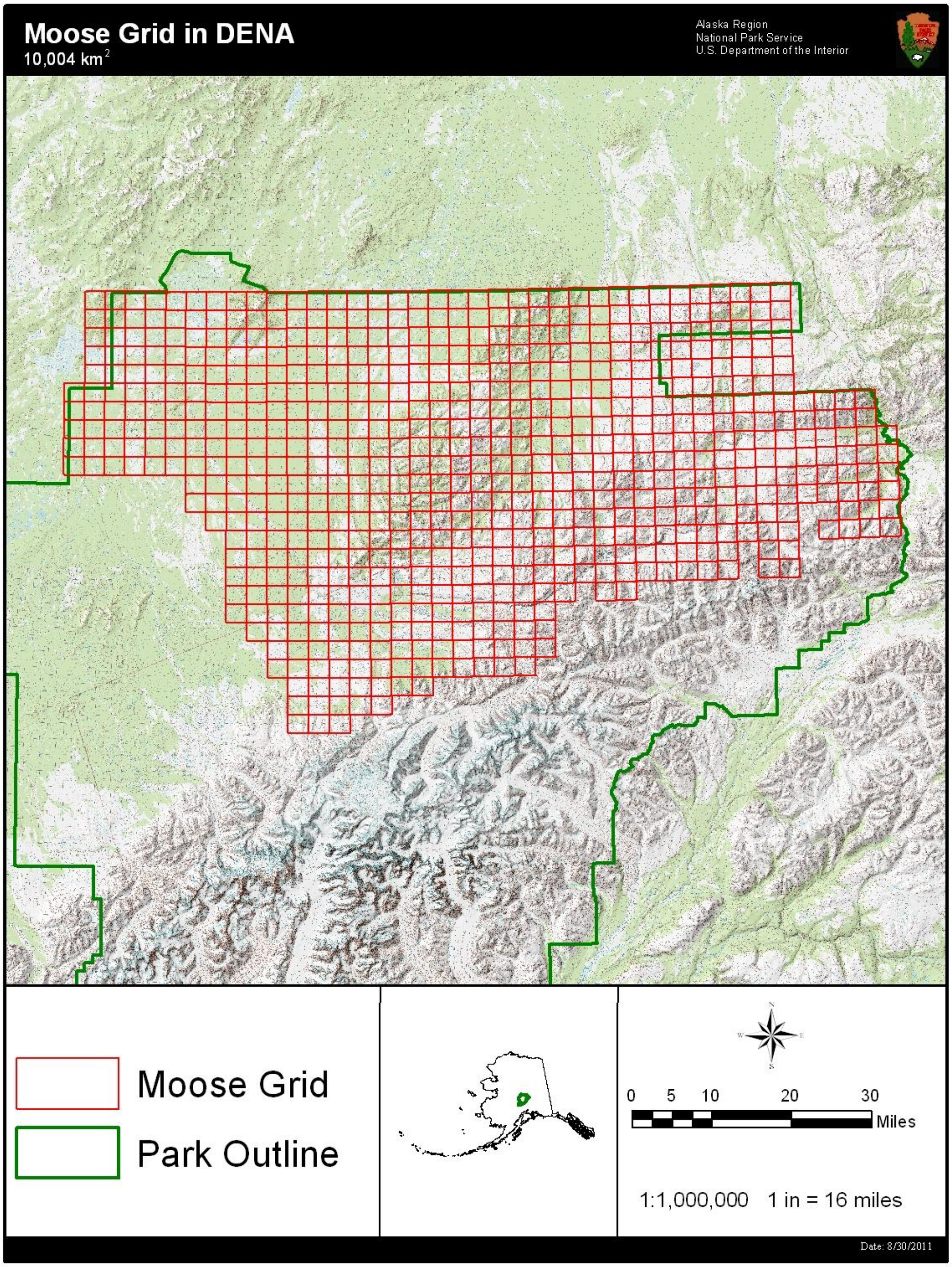


Figure 3: Moose Survey Grid in DENA (10,004 km$^{2)}$. This was the area surveyed in November 2004 and 2008.

Standard Operating Procedure (SOP) # 3 Survey Methods and Flight Patterns

Version 1.0 (August 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Overview

This Standard Operating Procedure explains how to conduct the sampling of the moose survey units. It explains; (1) how to divide the survey area up into sub areas; (2) various flight patterns used to survey the units; (3) placing observed moose into sex and age categories; and (4) how to manage the data from each days flight. Most of these instructions are taken directly from Gasaway et al. (1986), Ver Hoef (2000), and Kellie and Delong (2006).

I. How to divide the survey area into flight areas

The survey area should be divided up into reasonable geographic regions and each aircraft assigned to one or more regions. From a safety standpoint, this ensures separation of aircraft to avoid midair collisions. An aircraft radio frequency should be agreed on and aircraft should talk to each other frequently as a flight following safety measure as well.   From a survey management perspective, separate regions help to efficiently manage the aircraft and allocate survey units to each survey team. Each aircraft should go out each day with maps of the entire survey area and knowledge of which units have been surveyed on previous days in their region AND nearby regions. In this way, if unforeseen weather conditions prevent flying in the area where units are assigned, each aircraft is independent of the survey Project Leader (who may not be in direct communication) and can make decisions on their own as to which alternate units they should fly. If the aircraft must move into a different region they MUST first make contact with the aircraft assigned to that region to learn which units have already been done that day and to allocate the remaining units for the day. This method also allows aircraft to pick up an additional unit at the end of the day when returning to base, when they have enough fuel and daylight to sample a unit on the way home but not enough fuel and daylight to move to a unit further away. This helps to optimize the efficiency of each survey aircraft.

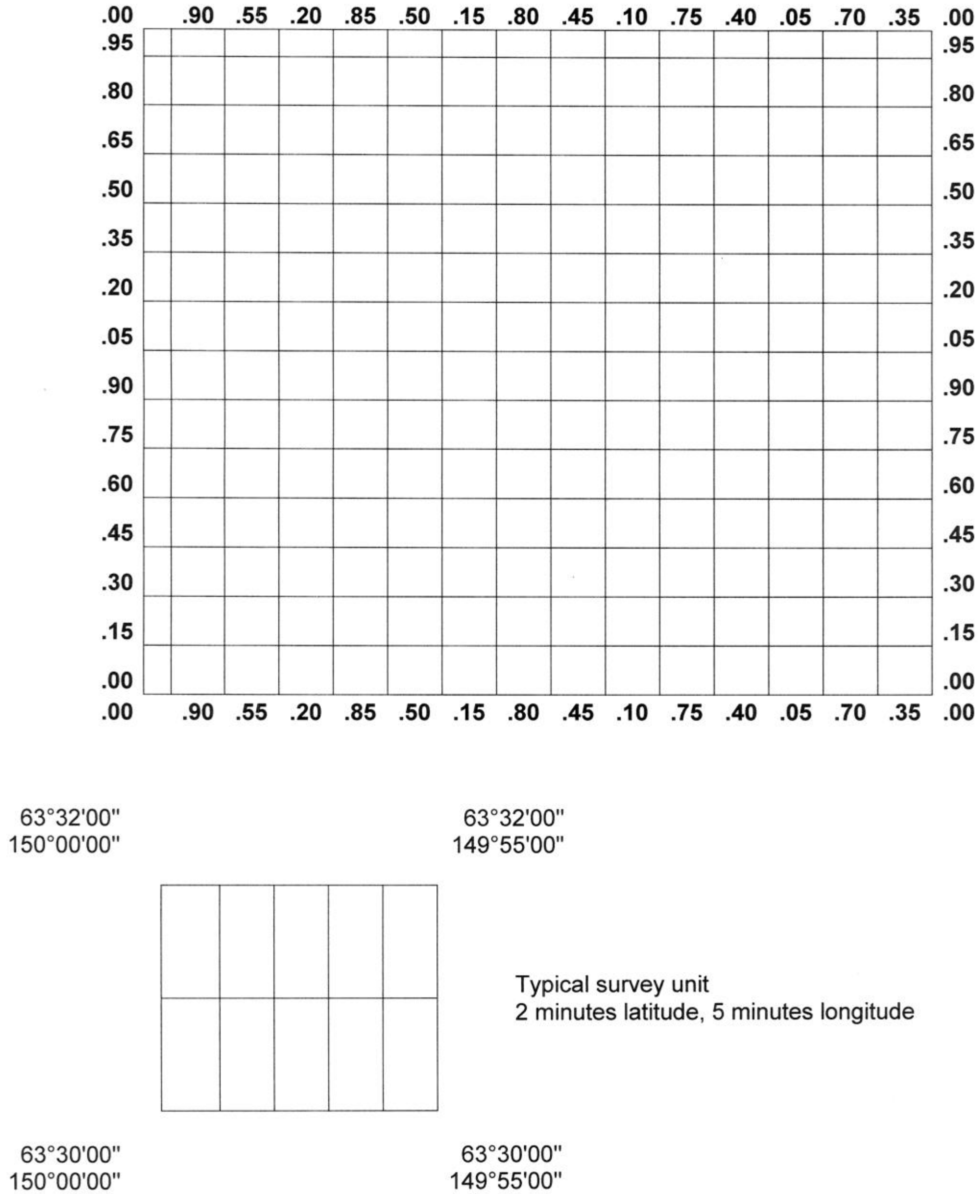
II. Survey search effort and flight patterns

Search effort has traditionally been reported in minutes of search time per square mile and will be here as well, rather than making a conversion to square kilometers. Ver Hoef (2000) recommends an average search effort of about 8 minutes/mi^2 which will equate to 30 – 50 minutes to complete a sample unit. These times should be used only as a general guide. Units with heavy spruce cover will require more search effort, and units in open country can be completed very quickly. The time spent circling each moose group and classifying the moose in it is included in the search time. The goal is to see every moose in the unit, and this will have to be evaluated by each survey team as they complete each unit. When a unit is completed, it is not uncommon to go back to some areas of thicker vegetation and look them over one more time. Studies have shown that even at 12 to 14 minutes/mi^2 some moose are still missed (Gasaway et al. 1986, Boertje and Kellie 2007), so Ver Hoef's (2000) assumption of 100% sightability is being violated. Sightability correction factors have been estimated by ADF&G for interior Alaska based on past Gassaway intensive surveys and tests with radiocollared moose (Boertje and Kellie 2007).

Flight patterns are dictated by the terrain and vegetative cover. In flat terrain with fairly open vegetation, parallel transects about 0.2 mile / 0.3 kilometer apart can be flown at 60 – 70 mph and 200 to 300 feet off the ground (see Figure 1 and diagrams in Kellie and Delong pages 34 - 35). Height should be greatest when flying over tall timber. In steeper terrain, the flight pattern will have to switch to flying elevational contours, circles, and flights along ridges and creeks. If particularly thick stands of spruce are encountered, it can help to fly linked circles across the stand. This allows looking more straight down into the spruce stand. Circling is also effective at the heads of valleys or over the ends of ridges. When flying the survey unit, it is not necessary to be overly concerned with the exact boundary of the survey unit except when a moose is found close to the boundary. At that time, the GPS should be used to determine whether the moose is in or out of the unit. It is important to fly one or more circles around each moose group seen to classify it and make sure no other moose are nearby. Additional moose are often found nearby when circling what was thought to be a single moose. Some 'cows' will be found to have very small antlers and to actually be yearling bulls, so a close look at each apparently antlerless moose is required.

The pilot's main responsibilities are: to fly safely, to monitor where the plane is relative to the sample unit boundary, and then to spot moose. It is the observer's responsibility to look for moose, write down the data, and keep track of which units have been completed and which need to be surveyed. The pilots are frequently skilled observers and often spot the majority of the moose first.

Figure 1. Sample grid pattern for searching rectangular moose survey units (pattern of flight for flat terrain only; direction of flight is either north-south or east-west, not both). The grid pattern adds or subtracts .35 minutes of longitude or .15 minutes of latitude to determine the spacing between transects. The resulting transects are about 0.2 miles apart.



III. Data on Moose Groups: Classification and Location

Classifying moose into sex and age classes is fairly straightforward. Calves are identified by their smaller size and shorter heads and faces. Lone calves are rare but may be seen. Bulls are easily differentiated from cows by the presence of antlers, but some yearling bulls can have very small antlers that may not be immediately noted at first observation. A close look at each cow is needed to be sure that it is not a yearling bull with small spike antlers. Bulls are classified into Large, Medium, and Yearling categories. Yearlings are defined as any bull with spike or single-forked antlers. Studies by ADF&G have shown that yearling bulls can grow palmated antlers up to 30 inches across, and spike/fork bulls may represent only 40%-60% of the yearling cohort in a given year assuming adequate nutrition (Gasaway et al. 1983, Gasaway et al. 1992). Medium bulls are those with antler spreads larger than a yearling but smaller than 50 inches. Large bulls are those with antler spreads of 50 inches or more. Keep track of the number of single-antlered bulls to monitor the amount of antler shedding, particularly in later season surveys.

The GPS coordinates of each moose group should be recorded from the aircraft's GPS, which should be set to display in the WGS-84 Alaska datum. All coordinates should be in the NPS standard degrees + decimal minutes format. An alternative is to save waypoints in the observer's GPS and merely record waypoint numbers. A program such as DNR Garmin (http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html) can then be used to upload the latitude and longitude data from the GPS units. The recording of coordinates for moose seen can be of great value for stratification and for many other needs in subsequent years, and by saving the data as a waypoint it adds very little to the time required to perform the survey, although there is office and data processing time added after the survey. If waypoints are saved in the GPS, be careful to know what datum the waypoints are downloaded in. Some Garmin GPS units will *display* in NAD 27, but *download* in WGS 84.

IV. How to manage the data from each days flying

After each day's flying the data sheets should be gathered from each aircraft and the data entered into the Excel spreadsheet that contains the sample units organized by stratum and unit number (an example of this Excel file can be found in the 'Supplemental Materials' folder at the CAKN web site: ExampleDataFileGeoSpatialAnalysis.xls). This data should then be moved to a text file in the format described by Reed (1989) and run through MOOSEPOP or GSPE software to get a preliminary daily population estimate and confidence interval. Follow the directions described in detail in Reed (1989) or Delong (2006). Back up both files each night.

V. References

Boertje, R. D. and K. A. Kellie 2007. ADF&G memo dated May 22, 2007 to Area Biologists. Subject: Developing a sightability correction factor (SCF) for early winter GSPE moose surveys in forest-shrub habitats of Interior Alaska.

DeLong R. A. 2006. GeoSpatial population estimator software user's guide. Alaska Department of Fish and Game, Fairbanks, Alaska, USA. 72pp.

Gasaway, W. C. R. O. Stephenson, J. L. Davis, P. E. K. Shepherd, and O. E. Burris. 1983. Interrelationships of wolves, prey, and man in interior Alaska. Wildlife Monograph 84. 50 pp.

Gasaway, W. C., S. D. Dubois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Papers, University of Alaska. No. 22. 108pp.

Gasaway, W. C., R. D. Boertje, D. V. Grangaard, D. G. Kelleyhouse, R. O. Stephenson, and D. G. Larson. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildlife Monograph 120. 59pp.

Reed, D. J. 1989. MOOSEPOP program documentation and instructions. Alaska Department of Fish and Game. 15pp.

Ver Hoef, J. M. 2000. SMOOSE: A spatial moose survey estimation method. Alaska Department of Fish and Game report, Fairbanks, Alaska. 4pp.

Standard Operating Procedure (SOP) # 4 Data Management

Version 1.0 (August, 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Overview
This SOP documents basic data management for the Central Alaska Network (CAKN) moose monitoring vital sign. A Microsoft Access database named "CAKN_Moose.mdb" will be used as a working database for this vital sign. Export files from this database will be used to run custom statistical applications historically used for moose surveys in the CAKN parks. These applications are MOOSEPOP, used in the field to determine survey progress, and the GSPE software on ADF&G's web site: "Winfonet" (*http://winfonet.alaska.gov*), formerly called SMOOSE, used for final analysis after data are collected, verified and validated. This SOP provides instructions for data entry, data validation, and database administration of the monitoring data collected by the Moose Monitoring Protocol for the CAKN. This SOP also documents the database tables used for basic data summary. This SOP has been developed following strategies and guidance for data handling and quality assurance/quality control in the CAKN Data Management Plan posted at *http://www.nature.nps.gov/im/units/cakn/DataMgt.htm*. Microsoft Access is the primary software environment for managing moose data.

I. Managing the data as it comes in each evening

After each day's flying the data sheets are gathered from each aircraft and the data entered into a field version of the CAKN_Moose.mdb database that contains the sample units organized by stratum and unit number (historically done in Excel; an example can be found in Excel file: ExampleDataFileGeoSpatialAnalysis.xls found in the 'Supplemental Materials' folder for this vital sign on the CAKN web site). A file in this format is used as the input file to GSPE for the final analysis of the survey data (Ver Hoef 2000). Currently, GSPE may be accessed and run only via a website (*http://winfonet.alaska.gov*). For a daily analysis, the data are exported to a text file in the format described by Reed (1989) (see the example text file in Appendix C) and run through MOOSEPOP (or MODPOP) to get a daily population estimate and confidence interval. Follow the directions described in detail in Reed (1989). Both files are backed up each night to a laptop computer and onto an external "thumb" drive.

Suggested Improvement: This process could be improved by developing a version of the GSPE software that can be loaded on a laptop and accepts the Access database file as the input file. The need for MOOSEPOP would be eliminated, and only one file would be necessary (no converting from Access to Excel).

II. Software for data analysis

As noted above, two software packages now exist to analyze moose survey data. MOOSEPOP (or MODPOP), developed in the mid 1980's, analyzes the data for the stratified random sampling design (Gasaway et al. 1986, Reed 1989). MOOSEPOP/MODPOP is now used to get daily estimates and confidence intervals to monitor the progress of the survey. These results may be used to extend the survey but do not otherwise affect how the survey is conducted.

The GSPE software, developed in the late 1990's, is used for the final analysis using a geo-spatial analysis routine (Ver Hoef 2000, 2001, 2002, Delong 2006). GSPE software may be used only via the website (see above) and a username and password are required. The site is managed by Rob DeLong (ADF&G Fairbanks). Rob needs to be sent the Access database export file (in Excel format) from each survey to be posted on the web site. The user can then go to the web site and run the analysis. An example file can be found in the 'Supplemental materials' folder in the CAKN web site ExampleDataFileGeoSpatialAnalysis.xls. Again, development of a version of the GSPE software that may be run on a laptop would greatly facilitate the process and allow for in-field analysis.

III. Data Entry and Validation

This section of the Data Management SOP provides instructions for how the original data sheets coming back in from the field (after the moose survey has been completed) are reviewed and archived, and how data on the datasheets are entered into the CAKN Moose Database (*CAKN_Moose.mdb*). The NPS Project Leader will bring the original field data sheets back from the field, organize them by sample unit number, make photocopies and file them in a fireproof safe.

Needed Items/Elements:

1. One technician familiar with the moose data and procedures, and proficient typing ability sufficient to quickly enter data into computerized forms.
2. Copying machine
3. Fireproof safe or cabinet
4. Computer loaded with current versions of Microsoft Access and with access to *CAKN_Moose.mdb*.

Procedures:

1. **Copy the original data sheets**. As soon as possible upon returning from the field, make a copy of each original field data sheet. Review each copied data sheet for clarity. The copied data sheets will be used for data entry so it is important that the copied data sheets are readable.

2. **Archive the original data sheets**. Organize the original field data sheets by sample unit and store in the designated fireproof safe or cabinet used by the Moose Monitoring Protocol staff.

3. **Proof the copied data sheets**. Proofread the copied datasheets, making sure that they have been filled out completely. All data sheets should have been reviewed for completeness while in the field. However, some deficiencies in data recording may not be identified until all data sheets have been reviewed as a group, and some errors are inevitable.

4. **Mark corrections on copied data sheets with red pen.** Any corrected errors, or changes made by the data "proofer" (to be entered differently into the database than they appeared on the original data sheet) should be circled and corrected using a red fine-point Sharpie marker. Notes, in red ink, should be written on the margins or in the comments section whenever necessary to document the reason for the corrections.

5. **Enter the data into CAKN_Moose.mdb**. The technician will enter all of the data into the MS Access database using the data entry form.

    a. The data entry form is structured very similarly to the field data form and the drop-down lists will facilitate easy transfer of information from the datasheet to the database.

    b. All information that is included on a data sheet should be included in the database.

    c. Sample units without moose will contain supplemental data and should note that "no moose were seen" in the comments section to distinguish that the sample unit *was* in fact sampled.

    d. Once all data from each data sheet has been entered, the technician will initial and date the bottom of that sheet.

6. **Verify Initial Data Entry**. When all data for a given data entry bout have been entered, the same person that entered the data (Technician) will proof the data in the database, reviewing the data forms and sorting summaries (from queries) to check for typos, errors, and blank fields. As each datasheet is verified, date and initial the sheet. Moose locations can be displayed on a map to aid in error checking the entered coordinates.

7. **Backup CAKN_Moose.mdb**. Once the proofing process has been completed, Technician #1 will save the *CAKN_moose_be.mdb* (Note the "be"!) backend database into a backup file on the appropriate backup drive for that park unit. The backup file name will consist of the normal file name with an extra underbar ("_") and 8 digit date (as in "*CAKN_Moose_be_07132005.mdb*"). The backend database file will similarly be saved onto a CD-ROM along with any additional files deemed important. The CD-ROM

will then be labeled as "CAKN Moose database backup" (with the date clearly written as well) and placed in a fireproof file cabinet.

8. **Inform the Project Leader that data entry for the current year is complete.** The data are ready for analysis.

IV. Database Administration

This section of the SOP addresses administration of all data and electronic files relating to the Moose Monitoring Protocol. The data management procedures common to all monitoring protocols implemented by the CAKN monitoring program are outlined in the Network Data Management Plan (*http://www.nature.nps.gov/im/units/cakn/DataMgt.htm*).

Procedures:

1. **Data Maintenance**. Any editing of archived data is accomplished jointly by the Project Leader and Data Manager. Every change must be documented in the edit log (captured in the database itself) and accompanied by an explanation that includes pre- and post-edit data descriptions. All data collected using this protocol is subject to the following two caveats: only make changes that improve or update the data while maintaining data integrity. Once archived, document any changes made to the data set.

2. **Computer File Organization**. Computer files will be organized according to the CAKN Data Management Plan directory structure implemented in the YUGA office in Fairbanks, Alaska.

3. **Version Control**. Before any major changes in either the frontend or backend for the CAKN Moose database, a copy is stored with the appropriate version number to allow for tracking of changes over time. Versioning of archived data sets is handled by adding an eight digit number to the file name that represents the month (two digits), day (two digits) and year (four digits). Frequent users of the data are notified of the updates, and provided with a copy of the most recent archived version. Changes to the database structure are recorded within a table of the database itself.

4. **Data Logs and Backups.** Basic data change logging and backup will follow the guidelines laid out in the CAKN Data Management Plan. Once the data are archived, any changes made to the data must be documented in an edit log. The edit log will be part of the database itself. Corrections or deletions as a result of data validation require notations in the original paper field records and in copies used for data entry about how and why the data were changed. Field forms can be reconciled to the database using the edit log. Once a data set has passed the quality checks, the data are loaded into the primary CAKN data server. Formal entry is also made in the I&M Data Set Catalog (metadata generation) and the NPS NR-GIS Data Store (see the CAKN Data Manager for guidance). Backup copies of the data are maintained on an AKRO server and the NR-GIS Data Store. Tape backups of all project databases residing on YUGA servers are made daily and stored in a fire- and water-proof safe.

V. Documentation of Database Tables

The following database table information is given in support of the operating procedures specified above and serves as documentation for the database design. The database consists of frontend and backend files (two files). The frontend contains basic data entry, editing, browsing and export forms (not yet developed). The backend contains the actual data tables (Figure 1).

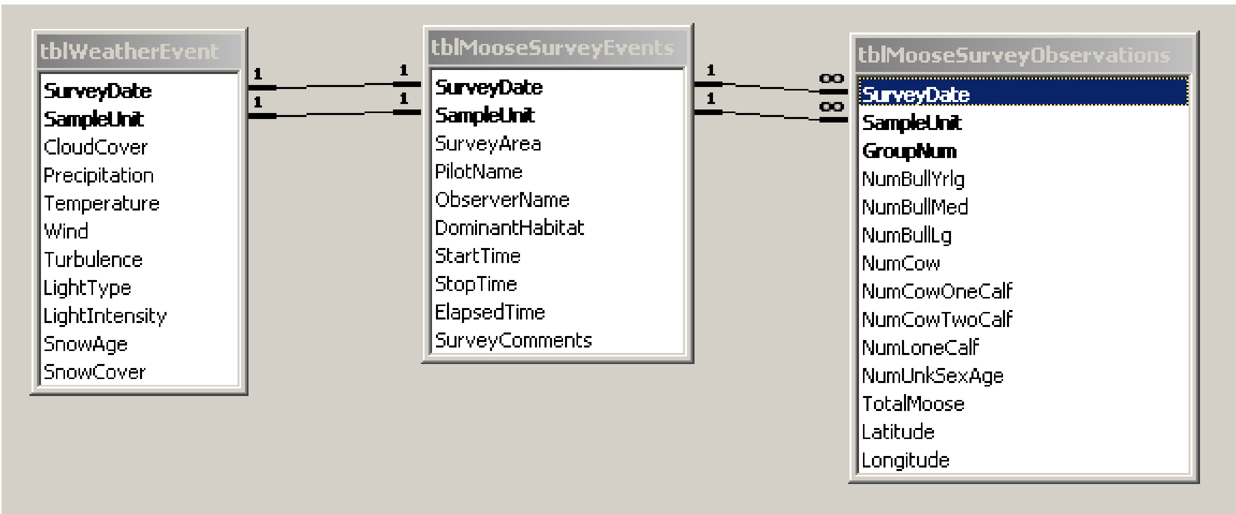


Figure 1. Table relationship diagram for CAKN_Moose.mdb. Core data tables only are shown.

Table Name: tblWeatherEvent

Description: Standardized table for storing information about the weather conditions. ***One record for each sample unit surveyed.***

Field Name	***Field Type***	***Field Size***	***Field Description***
Survey_Date	Text	50	Date sample unit was surveyed
Sample_Unit	Long Integer	50	Sample unit ID number
CloudCover	Text	50	brief description of visibility and sky conditions
Precipitation	Text	50	description of any precipitation/snow
Temperature	Text	50	temperature at start of unit in
Wind	Text	50	wind speed and direction in knots
Turbulence	Text	8	pick from list, 0, light , mod, severe
LightType	Text	8	pick from list bright or flat
LightIntensity	Text	8	pick from list high, med, low
SnowAge	Text	8	fresh, < 1week old, >1week old
SnowCover	Text	10	complete, some low veg showing, bare ground showing
OverallConditions	Text	20	pick from 1 of 4 categories to rate the survey of this unit

Table Name: tbl_MooseSurveyEvents

Description: table that stores a description of the survey unit, who surveyed it and how long it took. ***One record for each survey unit flown***.

Field Name	***Field Type***	***Field Size***	***Field Description***
Survey_Date	Text	50	Date sample unit was surveyed
Sample_Unit	Long Integer	50	Sample unit ID number
SurveyComments	Memo	0	Comments
SurveyArea	Long Integer	4	Area in square miles
PilotName	Text	50	Name of pilot
ObserverName	Text	50	Name of observer
DominateHabitat	Text	50	one of 6 categories, pick from list
StartTime	Long Integer	4	time of day when survey sample unit started
StopTime	Long Integer	4	time of day when survey of sample unit completed
ElapsedTime	Long Integer	4	Total time in minutes spent surveying the sample unit

TableName tbl_MooseSurveyObservations

Description: Primary table that stores data such as the number, composition and location of observed moose. ***One record for each moose group seen***, even if just outside the sample unit boundary.

Field Name	***Field Type***	***Field Size***	***Field Description***
Survey_Date	Text	50	Date sample unit was surveyed
Sample_Unit	Long Integer	50	Sample unit ID number
GroupNumber	Long Integer	4	sequential number starting at 1 for each moose group seen for each sample unit
NumBullYrl	Long Integer	4	Number of yearling bulls
NumBullMed	Long Integer	4	Number of medium bulls
NumBullLrg	Long Integer	4	Number of large bulls
NumCow	Long Integer	4	Number of cows with 0 calves
NumCowOneCalf	Long Integer	4	Number of cows with 1 calf
NumCowTwocalf	Long Integer	4	Number of cows with 2 calves
NumLoneCalf	Long Integer	4	Number of calves that are alone (cow is missing)
NumUnkSexAge	Long Integer	4	Number of moose that are unknown sex and age
TotalMoose	Long Integer	4	Total moose seen in sample unit
GroupSize	Long Integer	4	Total moose in moose group
Latitude	Long Integer	10	Latitude of moose group in decimal minutes
Longitude	Long Integer	10	Longitude of moose group in decimal minutes

VI. References

DeLong R. A. 2006. GeoSpatial population estimator software user's guide. Alaska Department of Fish and Game, Fairbanks, Alaska, USA. 72pp.

Gasaway, W. C., S. D. Dubois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Papers, University of Alaska. No. 22. 108pp.

Reed, D. J. 1989. Moosepop program documentation and instructions. Alaska Department of Fish and Game. 5pp.

Ver Hoef, J. M. 2000. SMOOSE: A spatial moose survey estimation method. Alaska Department of Fish and Game report, Fairbanks, Alaska. 4pp.

Ver Hoef, J. M. 2001. Predicting finite populations from spatially correlated data. 2000 Proceedings of the section on Statistics and the Environment of the American Statistical Association, pp. 93-98.

Ver Hoef, J. M. 2002. Sampling and geostatistics for spatial data. Ecoscience 9:152-161.

Standard Operating Procedure (SOP) # 5 Data Analysis and Reporting

Version 1.0 (August 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Overview
This Standard Operating Procedure explains the procedures for estimating moose population size and composition and other population parameters, and procedures for reporting moose monitoring data. The steps for changing the protocol are outlined in SOP #6, "Revising the Protocol".

I. Estimating Moose Population Parameters from Moose Survey Data

Procedures:

1. **Data sorting and validation**. Moose data collected from an aerial moose survey (as described in the Moose Monitoring Protocol and earlier SOPs) are made up of numbers of individual moose groups within surveyed sample units. Moose population parameters are estimated via a spatial statistical analysis method involving finite population block kriging (for a complete description of the statistical analysis, reference Ver Hoef (2001and 2002). This statistical analysis has been packaged in a software tool called the GSPE software by Jay Ver Hoef and Rob Delong (ADF&G, Fairbanks Alaska) and can be found at ADF&G's web site, WinfoNet: :http://winfonet.alaska.gov (Delong 2006). This software package requires the input data to be in a specific Microsoft Excel format. An example file, (CAKN_Moose_ExampleDataFileGeoSpatialAnalysis_12092004), can be found in the 'Supplemental Materials' folder at the CAKN web site.

   Before beginning to analyze moose population data, the database of moose locations should be reviewed to ensure that proper formatting has been adhered to and that no errors have occurred (see SOP#4 Data Management for more on error checking the data). One good error check is to display all moose locations on a map overlaid by the survey grid and check to be sure each moose group was within the survey unit.

2. Using GSPE software to analyze the data. Access to the GSPE software is through the ADF&G web site mentioned above. In order to access the site, biologists need to be set up with a user name and password. This free service is administered through Rob Delong (ADF&G Fairbanks). At the time of this writing the input data file for GSPE software must be e-mailed to Rob Delong and he can then upload it to the web site. ADF&G plans to create a feature at the web site to allow individual users to upload their own files. Once the file is uploaded, it will show up in a drop-down menu of other moose survey files. The appropriate file is chosen from the list, appropriate parameters for the survey are selected and the information is submitted by a mouse click. An output screen appears with all of the data parameters and a simple map of the survey area (Figure 1). This data can be copied and pasted to a WORD file to save it. This data can then be run to analyze the sex and age composition of the population. There is also a box that can be checked to run a simple stratified random sampling analysis (without geospatial analysis) on the same data, equivalent to running MOOSEPOP for a Gasaway et al. (1986) survey.

The Geo-Spatial analysis performed by GSPE software will be the analysis used by CAKN. The stratified random sampling analysis performed by MOOSEPOP can be an interesting comparison, but the primary use of MOOSEPOP will be to track the daily progress of a survey when no internet connection is available. MOOSEPOP is useful for this daily analysis because it can be loaded, stored and used from a laptop computer in the field. It is hoped that in the future, GSPE software will be available in a portable package. When biologists can upload their own data files to WinfoNet and if the survey is based at a place with internet access, GSPE software could be used at WinfoNet each night to track the progress of the survey.

3. Additional analyses not covered by GSPE software. There are some analyses that should be performed and reported for each moose survey that are not covered by GSPE software or MOOSEPOP. Moose density is not specifically calculated by GSPE software but can be obtained by simply dividing the population estimate by the survey area. Density is a measurement commonly reported from moose surveys. Search effort or search intensity is another commonly reported measurement that allows evaluation of the data quality. Search effort can be calculated by adding up the total minutes of search time from all of the units surveyed and dividing that by the total area of those units. Vegetative cover can vary tremendously among survey areas and survey units, and search time for individual units is highly dependent on vegetative cover. This must be factored in when evaluating search effort between different survey areas. Harvest data from ADF&G and USFWS/Office of Subsistence Management will also be collected as part of the CAKN moose monitoring program. A history of reported harvest is useful when evaluating the results of a moose survey relative to a proposed change in moose harvest regulations.

4. Analysis of moose population changes over time. At present, detecting a trend in a moose population from a series of population estimates is done by linear regression. A "t" test is used to evaluate the significance of a difference between two population estimates.

The limits of natural variation of moose populations in Alaska has not been determined. It will remain a challenge to interpret changes in moose numbers and distribution, and to identify truly unusual events. Statistical methods for identifying long-term trends in the moose population have yet to be developed, and investigation of these methods should form an important part of the monitoring program. The first step toward achieving this goal is to set a up a monitoring study where the same populations of moose are monitored on a regularly recurring basis for the long term, while at the same time monitoring environmental and other variables most likely to influence those populations.

II. Reporting of Moose Monitoring Data

Procedures:

1. General features of monitoring reports. Reports generated by the moose monitoring effort, and the vital signs monitoring program in general, will be designed to be promptly produced, appropriate to their target audience, widely available, and visually accessible. Concise summaries will be a part of each report produced. Reports will conform to guidelines set by the CAKN and the Alaska Region Inventory and Monitoring Plan. Graphical methods, maps, and other visual aids will be used to make results readily understood.

2. Annual administrative report and workplan. This report is designed to be incorporated into the annual Report to Congress on the nationwide Vital Signs Monitoring Program. It will be produced in the fall of each year. The report will account for the expenditure of funds and FTEs, and describe the objectives, tasks, accomplishments, and products of the monitoring effort during the previous fiscal year. The report is designed to improve communication within each park, the CAKN, the Alaska Region, and the National Monitoring Program. Its intended audience includes park superintendents, network staff, regional coordinators, and Servicewide program managers. The report will be written by the park biologists implementing the Moose Monitoring Protocol, and reviewed and approved by CAKN, the Alaska Regional Office and Servicewide Program managers.

3. Survey report. A report will be prepared for publication each March following a November survey, reporting the results of that particular moose survey. Surveys will likely occur once every three years, one survey in each of the three parks on a three year rotation. The report will contain early winter (usually November) population estimates from the currently reported survey as well as previous surveys. The annual report will provide a summary of all moose monitoring activities and data for the year, and describe the current condition of the moose population in the areas monitored. Any changes in monitoring protocols will be documented. The intended audience for the annual report includes park resource managers, network staff, and external scientists. The report will be written by the park biologists implementing the Moose Monitoring Protocol, and peer-reviewed within the CAKN.

4. Other reporting. In addition to the two scheduled annual reports, results of the moose monitoring effort will be presented at the biennial CAKN Vital Signs Monitoring Conference, and at other symposia, conferences, and workshops. Moose monitoring data will be provided to park interpretive staff for written and oral presentation to visitors. Significant findings will be reported in scientific journals and popular publications.

III. References.

DeLong R. A. 2006. GeoSpatial population estimator software user's guide. Alaska Department of Fish and Game, Fairbanks, Alaska, USA. 72pp.

Gasaway, W. C., S. D. Dubois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Papers, University of Alaska. No. 22. 108pp.

Ver Hoef, J. M. 2001. Predicting finite populations from spatially correlated data. 2000 Proceedings of the section on Statistics and the Environment of the American Statistical Association, pp. 93-98.

Ver Hoef, J. M. 2002. Sampling and geostatistics for spatial data. Ecoscience 9:152-161.

Figure 1. Output data from GSPE software for the total population estimate from YUCH November 2003 survey.

Population Estimate:	696.377
Standard Error:	101.0457

Confidence Intervals		
Confidence	Interval (moose)	Interval (proportion of the mean)
80%	566.8817 825.8724	0.1859558
90%	530.1716 862.5825	0.2386716
95%	498.331 894.423	0.2843948

Sample Details

Total Samples

	Stratum	N
1	H	188
2	L	378
3	TOTAL	566

Total Area

	Stratum	Area
1	H	1049.027
2	L	2107.922
3	TOTAL	3156.949

Sample Sizes

	Stratum	n
1	H	61
2	L	45
3	TOTAL	106

Area Sampled

	Stratum	Area
1	H	340.155
2	L	251.263
3	TOTAL	591.418

Moose Counted

	Stratum	Counted
1	H	129
2	L	30
3	TOTAL	159

Figure 1. Output data from GSPE software for the total population estimate from YUCH November 2003 survey (continued).

Estimate Details		
Stratum	H	L
Empirical Semi-Variogram	distance gamma np 1 4.518855 0.2084972 132 2 9.896862 0.1794275 250 3 15.511937 0.1760223 174 4 21.573619 0.2573027 240 5 28.668768 0.3287961 268 6 34.579841 0.3987795 394 7 40.670654 0.3246223 422 8 46.965780 0.2932065 414	distance gamma np 1 4.609238 0.04292144 32 2 10.022674 0.07232881 124 3 15.515052 0.06505335 92 4 21.588563 0.09328201 150 5 28.314528 0.05142573 116 6 34.279135 0.09832833 112 7 40.441262 0.08569939 146 8 46.719861 0.02895668 148
Parameter Estimates	nugget parsil range 1 0.2069832 0.1694054 27.66705	nugget parsil range 1 0.07687872 4.669404e-10 23.65940

Sampling and Stratification

Green blocks = low stratum, Red blocks = high stratum, Numbers = number of moose counted in that sample unit, Units without numbers were not surveyed. YUCH 2003 survey.

Standard Operating Procedure (SOP) # 6 Revising the Protocol

Version 1.0 (August 2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Overview

This Standard Operating Procedure explains how to make changes to the Moose Monitoring Protocol for the CAKN, and to the accompanying SOPs, and how to track these changes. Observers asked to edit the Protocol narrative or any one of the SOPs need to follow this outlined procedure in order to eliminate confusion in how data are collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies.

Procedures:

1. The Moose Monitoring Protocol narrative for the CAKN and accompanying SOPs have attempted to incorporate the most sound methodologies for collecting and analyzing moose population data. However, all protocols, regardless of how sound, require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken.

2. All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by CAKN staff. However, if a complete change in methods is sought, than an outside review is required. NPS regional and national staff with familiarity in large mammal research and data analysis will be utilized as reviewers. Also, experts in moose research and statistical methodologies outside of the NPS will be utilized in the review process.

3. Document edits and protocol versioning in the Revision History Log that accompanies the Moose Monitoring Protocol text and each SOP. Log changes in the section being edited only. Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Record the previous version number, the date of

revision, and the author of the revision. Identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.

4. Inform the Data Manager about changes to the Moose Monitoring Protocol or SOP so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the Data Manager to accompany changes in the Protocol or SOPs. Post new versions on the internet and forward copies to all individuals with a previous version of the affected Protocol text or SOP.

Appendix C. Supplemental Material

Example data files for MOOSEPOP

MOOSEPOP requires 2 separate files, a characteristic file and a data file, both ASCII text files.

Example of a characteristic file:

3 Sample Data for MOOSEPOP (Gasaway et al, 1986)
1 506.9   43   low
2 308.8   26 S medium
3 223.7   19 S   high

Example of a data file:

Unit	Stratum	Area	YrlBull	MedBull	AdBull	Cow	Cow/1calf	Cow/2calf	LoneCalf	Unknown	Total
61	2	5.2	0	0	0	0	0	0	0	0	0
15	2	5.2	0	0	0	0	1	0	0	0	1
16	2	5.2	0	0	4	0	0	0	0	0	4
57	2	5.2	0	0	0	2	1	0	0	0	4
58	2	5.2	0	0	0	1	0	1	0	0	4
85	2	5.2	0	0	0	0	0	0	0	0	0
86	2	5.2	0	0	0	0	0	0	0	0	0
87	2	5.2	0	0	0	0	0	0	0	0	0
393	2	5.2	0	0	0	3	1	0	0	0	5
337	2	5.2	0	0	0	0	0	0	0	0	0
338	2	5.2	0	0	0	0	0	0	0	0	0

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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National Park Service
U.S. Department of the Interior

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