

U.S. Department of the Interior

National Park Service

Moose Monitoring Protocol for the Central Alaska Network

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Central Alaska Inventory and Monitoring Network

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Important Note: The Moose Monitoring Protocol consists of this Protocol Narrative and the following Standard Operating Procedures (SOPs):

SOP 1:	Survey preparation and Timing
SOP 2:	Selecting the Survey Area
SOP 3:	Survey Methods and Flight patterns
SOP 4:	Data Management
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I. Background and Objectives

This document is the narrative for the Moose Monitoring Protocol for the Central Alaska Network. The narrative explains the rationale for moose monitoring and sets forth the specific objectives to be achieved. The narrative provides context for the Standard Operating Procedures that provide the details on how to carry out the protocol.

Issues being Addressed and Rationale for Monitoring Moose Populations

Monitoring of animal abundance and distribution was ranked 3rd among all potential vital signs evaluated by the CAKN. 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. 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 also including 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). They are crucial to many subsistence communities as a primary source of food that may be harvested on most NPS land in Alaska, in addition to being harvested by the general public on NPS Preserve lands. Moose are one of 6 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, unanswered, 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 ignored, easily dismissed, or glossed over 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. All these variables would be monitored over the long term in the same places at the same time, 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 will cause 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 and hotly debated 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. General statewide hunting is allowed throughout all Alaska National Preserves and subsistence harvest by qualified residence is allowed within 12 of 13 park units created in the Alaska National Interest Lands Conservation Act of 1980 (ANILCA) including the 3 CAKN park units (Denali National Park and Preserve, Wrangell-St.Elias Park and Preserve, and Yukon-Charley Rivers National Preserve). ANILCA also mandates that harvest of fish and wildlife be consistent with the conservation of natural and healthy populations within a national park or 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 2 decades, population monitoring on federal lands by the Alaska Department of Fish and Game (ADF&G) has consistently decreased, 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 National Park Service (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 be monitoring willow and other forage plants moose depend on. Weather data, predominately snow depths, can be used as an indicator to winter severity and any correlations with overall 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 Denali) and one of the primary goals of many visitors is viewing and photography of wildlife, particularly the 6 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 National Park Service to ensure 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.

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 quadrat sampling (Evens et al. 1966), aerial quartile density surveys (Croskery 1975), line transect sampling (Burnham et al. 1980), and aerial indexes of relative abundance based on the number of moose seen per flight hour (Gasaway et al. 1979, Gasaway et al. 1981, Gasaway 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 3 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).

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

II. Sampling Design

Rationale for Selecting this Sampling Design Over Others

As mentioned in the history section above, a few different techniques have been used to measure moose abundance in Alaska. One technique developed by the Alaska Department of Fish and Game has evolved into the 'industry standard' for measuring moose abundance in Alaska and is the only technique used by ADF&G and most federal agencies in interior Alaska and the Yukon. Pellet counts are still used to some degree in southeast Alaska in conjunction with aerial surveys (Neil Barten, ADF&G, Douglas, Alaska, personal communication). Three of the 4 authors of this protocol have used this technique numerous times, two since 1987 (Meier et al. 1987) for the

National Park Service in Alaska. The stratified random sample design developed by Gasaway (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 5 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 1986). The history of wide use and acceptance over nearly 20 years indicates the protocol described here meets these 5 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 3 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 km² 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 area on the south side of Denali). Moose survey areas were placed in each park in order to co-locate with as many vital signs as possible, yet cover the 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 such as the North side of Denali. 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 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, 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 more 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 2 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 - early December can cause a survey to become uneconomical depending on the distance of survey units from the base of operation. The later the 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). Therefore, the population estimate in November may not be representative of the harvested population in September. 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 3 parks in CAKN. Furthermore, moose populations usually will change slowly enough that a population estimate once every 3 years will be adequate to detect a change in abundance, distribution or composition. One survey will be conducted annually by CAKN rotating through the 3 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 will 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:cow ratio. Correlations can then be made between any measured trends in habitat change such as abundance of willow, 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 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 #2 aircraft and pilot

requirements). One observer should be lined up for each aircraft, and at least one alternate pilot and observer should be made aware that they may be asked to participate in the survey should the need arise. The biologists and all observers should review this entire protocol, including all of the SOPs, and review Gasaway (1986). Biologists should pay special attention to the tasks described in SOP #1 "Survey Preparation" and SOP #2 "Aircraft and Pilots". The observers need to review SOPs #2 and #5 "Conducting the Survey". Enough maps need to be made so that there are 2 full sets of maps of the sample units for each aircraft (one for the pilot and one for the observer) and 2 extra copies, one of which can be used as a master map at the base camp for the survey. Numerous copies of the data form in 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 #4 "Survey area, Sample Units, and Stratification"); 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. The primary assumption needs to be that there is little variation in moose abundance between sample units in that area. For example, there are likely no sample units (or very few) with more than 5 moose in them throughout the area in question.

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 CAKN's climate stations or MODIS images will 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 old Gasaway (1986) method. Depending on habitat types, day length, snow conditions, and the amount of ferry time to get to assigned survey units, a single aircraft can sample between 6 and 12 units per day. With 4 or 5 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 5 or 6 days with 4 or 5 aircraft. When scheduling aircraft, at least 1 or 2 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 (1986) goes 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 (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 8 minutes per square mile vs 4 or 5 minutes per square mile) with the assumption of 100% moose sightability. Jay Ver Hoef is now working on incorporating a sightability correction factor into his analysis.

The details in SOP #4 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 independent of the PI for making decisions on which units to fall back to if weather prevents flying assigned units, to have all aircraft communicate on an agreed to 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 2 or 3 adjacent units can be flown concurrently. Flat terrain can be flown in transects 0.2 miles apart. Steeper terrain will require flying 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 – 50 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 should be keyed in on to help find moose in the sample 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.

Each evening, all data sheets from each plane are collected and the data entered into 2 specific formats. One format is a ASCII text file that is then read into MOOSEPOP, a computer program, from which daily 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, SMOOSE.

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 ADF&G harvest data located at ADF&G's web site <http://winfonet.alaska.gov>, and will consist of numbers and sex of moose reported as harvested each year in the areas of interest within each of the 3 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. The second database was designed by Ver Hoef (2001) as the input file for SMOOSE, 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. SMOOSE 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 SMOOSE 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, SMOOSE 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 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 B. 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). SMOOSE 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 SMOOSE or MOOSEPOP formats is performed each evening after the data sheets are gathered from each aircraft. A SMOOSE 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 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 (see appendix A). This design allows error checking by verifying that the grand sum of columns is the same as the grand sum of rows. If the 2 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 data management SOP#4

Data archival procedures – see data management SOP#4

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, supervised by the Chief of Resources from each individual park. All CAKN biologists could participate as observers in each moose survey 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 automates report generation. The data manager is ultimately responsible to see that adequate QA/QC procedures are built into the database management system and appropriate data handling procedures 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 survey work (radiotracking is a good example). As surveys typically only last only one or two weeks, hiring observers specifically for the moose survey is not practical, and based on past experience it 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 longer 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 lost 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 km² with 4 aircraft. It is proposed to conduct one survey in each of the 3 CAKN parks once every 3 years in rotation.

Facility and Equipment Needs

Housing and food for 8 to 10 people will be required for 7 to 10 days where the survey is based. Arrangements will need to be made to preheat 4 or 5 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 4 or 5 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 OAS certification and contracting procedures. Aircraft must have functional radios for communication and coordination, 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 3 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 km² survey area. Fuel costs include delivery.

Table 1. Estimated costs by park for conducting a moose survey over a 10,000 km² survey area in each park assuming no stratification flights.

Estimated Costs	DENA	WRST	YUCH
Food (housing provided by host park)	900	900	900
Contract Aircraft 3 for 5 days (120 hrs @ 160/hr)	19,200	19,200	19,200
DOI agency Aircraft 1 for 5 days (40hrs @ 88/hr)	3500	3500	3500
Fuel 1600 gallons @ \$4.00/gal	6400	6400	6400
Total	30,000	30,000	30,000

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

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

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

- The 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 very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.
- When a 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 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 #7, "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.

VIII. References

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Appendix A. Moose Survey Data Form.

MOOSE SURVEY FORM

Page ____ of ____

Revised: 12/15/04

SEARCH IDENTIFICATION

SEARCH EFFORT

SEARCH TIMES (in minutes)

Date: _____	SU #: _____		
GMU: _____		~8 min/mi ²	Stop@ _____
Location: _____		(depends on terrain)	
Observer: _____			Start@ _____
Pilot: _____		Stratum: _____	
Aircraft Type: _____	Temp (F) _____	Area (mi ²): _____	Elapsed _____

OVERALL SURVEY RATING:	☐ Excellent	☐ Good	☐ Fair	☐ Poor
-------------------------------	---------------------------------	----------------------------	----------------------------	----------------------------

SEARCH CONDITIONS

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

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

Group No.	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		
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 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.											
19.											
20.											
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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. Example data files for MOOSEPOP

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

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	Strata	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	0	0	0	1
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

Appendix C. Example data files for SMOOSE

See example Excel file in “supplemental materials”

Moose Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 1

Survey Preparation and Timing

Version 1.0 (December 2004)

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 Summery

Prior to each survey, even as early as August, the 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. 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 Ver Hoef (2000, 2001, 2002). Enough maps need to be made so that there are 2 full sets of maps of the sample units for each aircraft (one for the pilot and one for the observer) and 2 extra copies, one of which can be used as a master map at the base camp for the survey. Numerous copies of the data form (see appendix A in the Protocol Narrative) 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) and Ver Hoef (2000, 2001, 2002). 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 km² in each of the 3 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 4 or 5 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 8 or 9 gallons per hour so using 10 gallons per hour as an average is safe. Plan on each survey aircraft flying 8 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 km² 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 (2 -3 times more per gallon) to be flown in on an airstrip where ski-equipped aircraft are required. As an example, using the above criteria and assuming 4 survey aircraft for 5 days and 1 stratification plane for 3 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, knowing fully well that the schedule will 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 can 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 at best 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 count for much.

7. Schedule the survey for a time when the area will most likely have good snow cover. For example, Denali will likely have adequate snow cover earlier in the year than Yukon-Charley.
8. Surveys should be scheduled for the time of year when most other 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. 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 day light 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.

II. Organizing Supplies and Equipment

Procedures:

1. Maps of the survey area should be prepared using a GIS such as ArcView. 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 are to be surveyed which are picked by a random draw.
2. The survey form (see appendix A in the Narrative) 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.
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 should be set up and example files brought along 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 2 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 2 or more weeks old, or snow of moderate age (between one and 2 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 1 or 2 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.

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Moose Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 2

Selecting The Survey Area

Version 1.0 (December 2004)

Revision History Log:

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

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 2 or more strata. Most of these instructions are taken directly from Gasaway et al. (1986) or Ver Hoef (2000).

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 mi² or 14.2 km². This grid can be developed in a GIS such as ArcView 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 km² or more, but most are 5000 km² to 10,000 km² with survey size usually dictated by budget. Survey areas of 10,000 km² 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 MOOSEPOP) 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 elevational 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 latitude 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 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 closer to specific geographic areas of interest. The maps in section V 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 that matter 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. The reason to stratify is to reduce the variability of moose density estimates by sampling strata. In some situations it is not reasonable to stratify. In general aerial stratifying helps a lot, but can be very expensive. To aerial stratify 700 units (about 10,000 km² at CAKN latitudes) would take 3 full days of Cessna 185 time and 360 gallons of fuel, totaling about \$8500 (2004 prices). 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 206) 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 4 strata of moose densities (low, medium, high, very high). Most surveys are done using 2 strata because it tends to be easier, 'safer'. There should be 4 people in the airplane; the pilot, a note taker/navigator and 2 observers. As the plane leaves a unit, the notetaker 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 2 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 a couple of times, a desktop stratification can save a lot of 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.

III. Selecting the survey samples

Once the survey area has been stratified the survey units must be randomized within each stratum, this is done prior to each individual survey. Sample units are then divided among the survey aircraft. Sample units are 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). 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 in it that can be helpful in deciding how many units of which strata will best reduce the variance (Reed 1989). Although the requirements for surveying low stratum units is 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.

IV. References

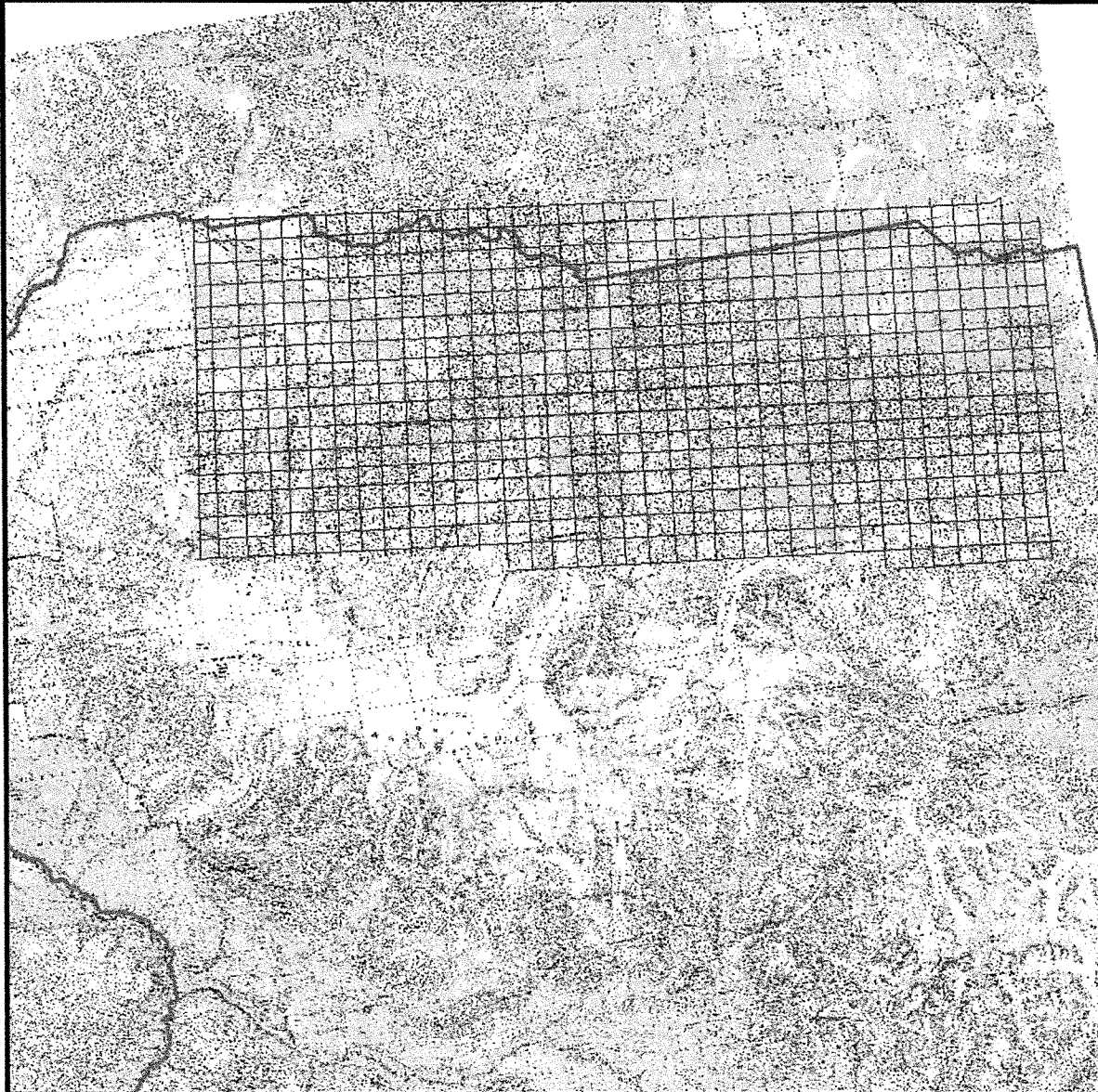
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V. Maps of defined survey areas in DENA and YUCH, WRST is a close approximation

Maps of DENA and YUCH are the defined survey area boundaries, WRST is a close approximation and needs to be fully defined.

Moose Grid in WRST (8,200 km²)

National Park Service
U.S. Department of the Interior



Moose Grid



Park Outline

Map Location



7.5 0 7.5 15 22.5 30 Miles

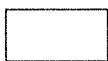
1 : 950,400 1 inch = 15.00 miles

October 20, 2004

A general idea of where the survey area will be. This area will need to be more specifically defined.

Moose Grid in YUCH (8,200 km²)

National Park Service
U.S. Department of the Interior



Moose Grid



Preserve Outline

Map Location

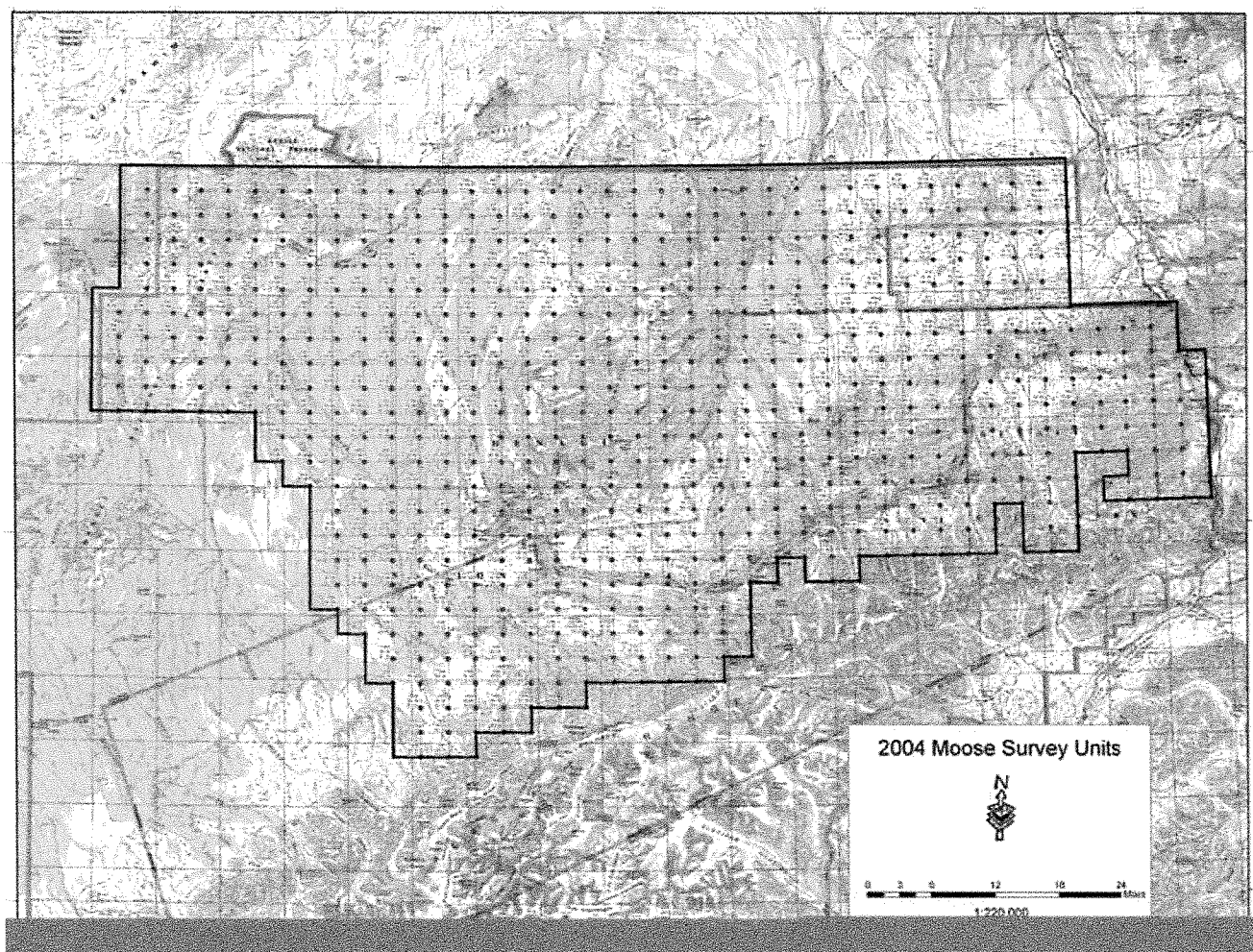


5 0 5 10 15 20 25 Miles

1 : 760,320 1 inch = 12.00 miles

October 20, 2004

This area of YUCH was surveyed in 1987, 1994 (partial), 1997, 1999, 2003.



Moose Survey Grid in DENA 10,004 km². This was the area surveyed in November 2004.

Moose Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 3

Survey Methods and Flight Patterns

Version 1.0 (December 2004)

Revision History Log:

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

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) or Ver Hoef (2000).

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 mid air 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 PI (who may be too far off to 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 work out which units have been done that day and how 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 to sample a unit on the way home but not enough fuel 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)

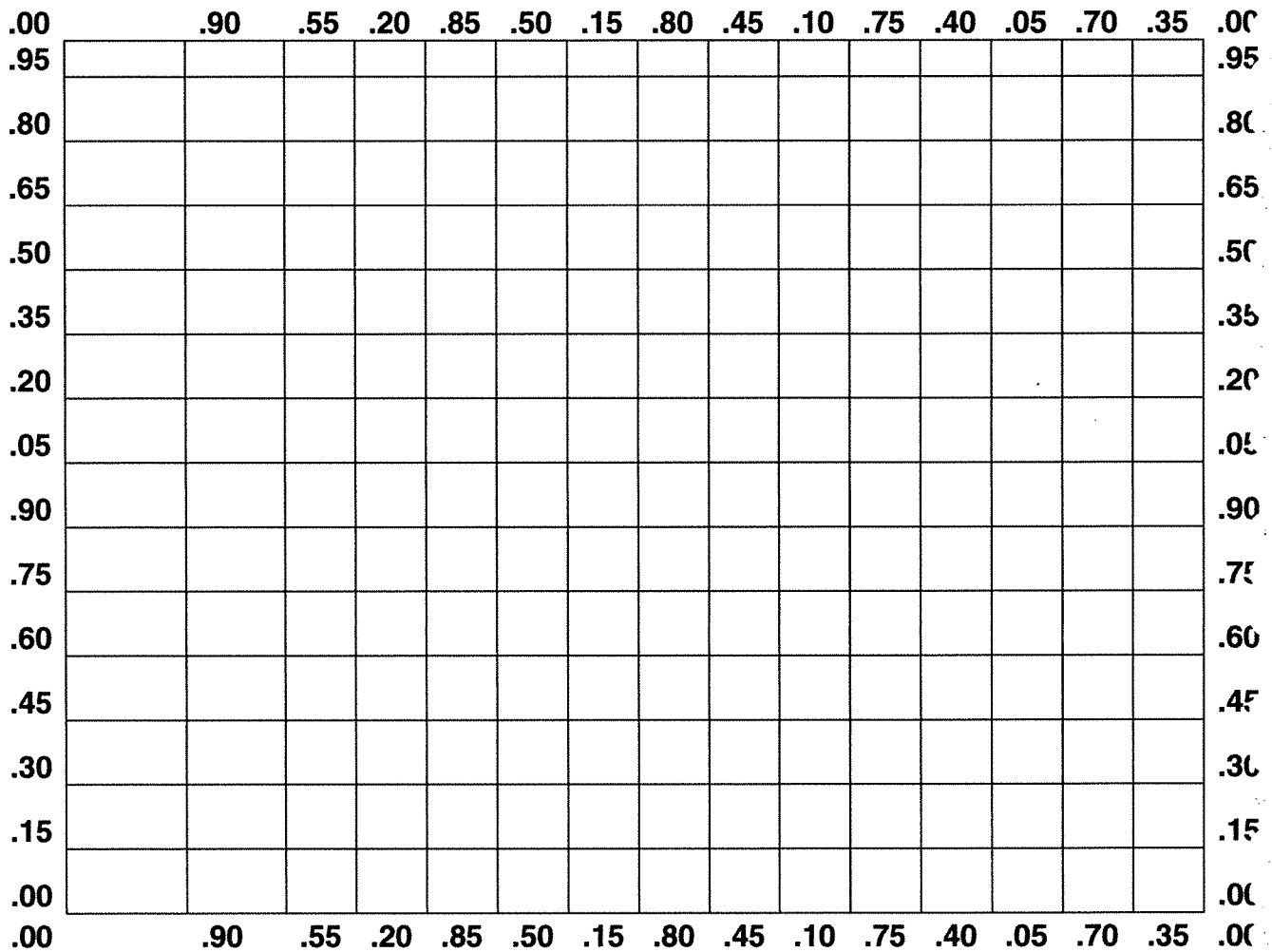
recommends an average search effort of about 8 minutes/mi² which will equate to 30 – 50 minutes to complete a sample unit. These times should be used only as a general guide. Units with heavy spruce cover will require more search effort, and units in open country can be completed very quickly. The time spent to circle each moose group and classify them is included in the search time. The goal to shoot for is to try and see every moose in the unit, and this will have to be decided on 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 it over one more time. Studies have shown that even at 12 and 14 minutes/mi² some moose are still missed (Gasaway et al. 1986), so Ver Hoef's (2000) assumption of 100% sightability is being violated. Current discussions are to revise the protocol to add some kind of sightability correction factor into the population estimation procedure, possibly based on standard sightability correction factors for broad cover types, but these have not been established yet.

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). 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 much better observers and often spot the majority of the moose first.

Figure 1. Pattern of flight for flat terrain only, is EITHER north-south OR east-west, not both.

GRID PATTERN FOR SEARCHING RECTANGULAR MOOSE SURVEY UNITS



63 32
150 00

63 32
149 55

63 30
150 00

63 30
149 55

Typical survey unit
2 minutes latitude, 5 minutes longitude

III. Sex and age classification

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 have been 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 obvious 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. 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. 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). 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 may be recorded from the aircraft's GPS, which should be set to display in the NAD-27 Alaska datum. Although the recording of coordinates for moose seen can be of great value for stratification and for many other needs in subsequent years, it is not free data and its value should be weighed against the time needed to record it. If waypoints are saved in the GPS, be careful to be sure 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 to get a daily population estimate and confidence interval. Follow the directions described in detail in Reed (1989). Back up both files each night.

V. References

- 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.

Moose Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 4

Data Management

Version 1.0 (December 15, 2004)

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 "SMOOSE", used for final analysis after data are collected, verified and validated. This SOP provides instructions for data entry and 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 SMOOSE for the final analysis of the survey data (Ver Hoef 2000?). Currently, SMOOSE 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 B of the Protocol Narrative) and run through MOOSEPOP 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 SMOOSE 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 developed in the mid 1980's analyzes the data for the stratified random sampling design (Gasaway et al. 1986, Reed 1989). MOOSEPOP 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.

SMOOSE developed in the late 1990's is used for the final analysis using a geo-spatial analysis routine (Ver Hoef 2000?, 2001, 2002). SMOOSE may be used only via the website (see above) and username and password are required. The site is managed by Rob DeLong (ADF&G Fairbanks). Rob also 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 SMOOSE that may be run on a laptop would greatly facilitate the process and allow for in-field analysis.

II. 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, organized 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 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 sheets. 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.
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” (that are entered differently into the database than they appear on the 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 will be displayed on a map to aid in error checking the entered coordinates.
7. **Backup CAKN_Moose.mdb on a zip disk.** 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 YUGA “K” drive (165.83.59.10). 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 in the YUGA office.

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

III. 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 that are common to all monitoring protocols implemented by the CAKN monitoring program are outlined in the Network the Data Management Plan (<http://www.nature.nps.gov/im/units/cakn/DataMgt.htm>).

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:

- 1) Only make changes that improve or update the data while maintaining data integrity.
- 2) 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.

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 (2 digits), day (2 digits) and year (4 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.

IV. 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).

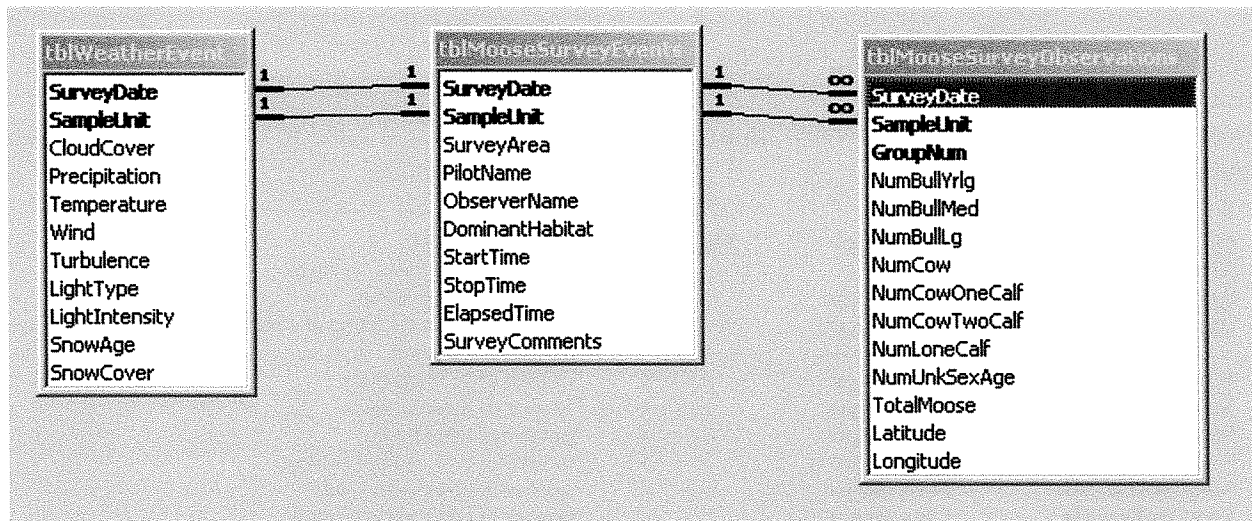


Figure 1. Table relationship diagram for CAKN_Moose.mdb. Core data tables only are shown.

Table Name: tblWeatherEvent

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

<u>Field Name</u>	<u>Field Type</u>	<u>Field Size</u>	<u>Field Description</u>
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 fairnehieght
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.*

<u>Field Name</u>	<u>Field Type</u>	<u>Field Size</u>	<u>Field Description</u>
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.

<u>Field Name</u>	<u>Field Type</u>	<u>Field Size</u>	<u>Field Description</u>
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

V. References

- 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.
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- 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.

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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.

Moose Monitoring Protocol for the Central Alaska Monitoring Network, National Park Service, Alaska

Standard Operating Procedure (SOP) # 5

Data Analysis and Reporting

Version 1.0 (December 2004)

Revision History Log:

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

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 Narrative 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 (2001 and 2002). This statistical analysis has been packaged in a software tool called SMOOSE 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>. This software package requires the input data to be in a specific 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 SMOOSE to analyze the data. Access to the software SMOOSE is through the ADF&G web site mentioned above. In order to access the site biologists needs 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 SMOOSE 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 the data parameters and a simple map of the survey area (Figure 1). This data can then be copy and pasted to a WORD file to save it. This same procedure 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 stratified random sampling analysis on the same data equivalent to running MOOSEPOP for a Gasaway et al (1986) survey.

The Geo-Spatial analysis performed by SMOOSE will be the analysis used by CAKN. The stratified random sampling analysis performed by MOOSEPOP can be an interesting comparison, however the primary use of MOOSEPOP would be to track the progress of a survey each night. The only reason to use MOOSEPOP for this daily analysis is because it can be loaded, stored and used from a laptop computer in the field. Hopefully in the future SMOOSE 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 SMOOSE could be used at WinfoNet each night to track the progress of the survey.

3. Additional analyses not covered by SMOOSE. There are some analyses that should be performed and reported for each moose survey that are not covered by SMOOSE or MOOSEPOP. Moose density is not specifically calculated by SMOOSE but simply dividing the population estimate by the survey area. Density is a measurement commonly reported from most 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 search time from all the units surveyed and dividing that by the total area comprised by those units. Vegetative cover can vary tremendously between survey units and different surveys, and search time for individual units is completely dependent on vegetative cover. This must be factored in when evaluating search effort between different survey areas. Harvest data is not so much an analysis, but is a summery of past moose harvest from the survey area. A history of reported harvest is useful when evaluating the results of a moose survey relative to a proposed change in moose harvest regulations.
6. Analysis of moose population changes over time. Right now, detecting a trend in a Moose population from a series of population estimates is done by linear regression. Determining if there is a difference between 2 estimates is analyzed using a t' test.

The limits of natural variation of a moose population 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 to achieving this goal is to set 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 all the variables most likely to influence those populations. Hopefully the CAKN is headed in that direction.

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 Central Alaska Monitoring Network 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 Central Alaska Network, 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, 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 (1 survey in each of the 3 parks on a 3 year rotation) monitoring and changes that might have occurred over the past 3 years. Thus, it will contain early winter (usually November) population estimates from the currently reported survey as well as all 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 Central Alaska Monitoring Network.
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.

- 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.

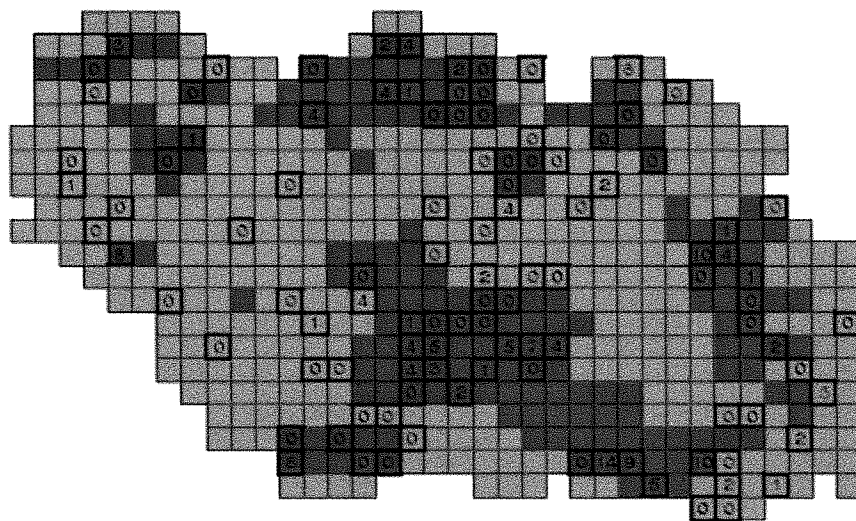
Figure 1. Output data from SMOOSE for the total population estimate from YUCH November 2003 survey.

		Confidence Intervals		
Population Estimate:	696.377	Confidence	Interval (moose)	Interval (proportion of the mean)
Standard Error:	101.0457	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		Total Area	Stratum Area	
	1	H 188		1	H 1049.027
	2	L 378		2	L 2107.922
	3	TOTAL 566		3	TOTAL 3156.949
Sample Sizes	Stratum n		Area Sampled	Stratum Area	
	1	H 61		1	H 340.155
	2	L 45		2	L 251.263
	3	TOTAL 106		3	TOTAL 591.418
Moose Counted	Stratum Counted				
	1	H 129			
	2	L 30			
	3	TOTAL 159			

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

Sampling and Stratification



-144.0 -143.5 -143.0 -142.5 -142.0 -141.5 -141.0

Longitude (Decimal Degrees)

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

**Moose Monitoring Protocol for the Central Alaska Monitoring Network,
National Park Service, Alaska**

Standard Operating Procedure (SOP) # 6

Revising the Protocol

Version 1.0 (December 2004)

Revision History Log:

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

This Standard Operating Procedure explains how to make changes to the Moose Monitoring Protocol Narrative for the Central Alaska Monitoring Network, and accompanying SOPs, and tracking 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 is 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 Central Alaska Monitoring Network (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. Regional and National staff of the National Park Service 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 Park Service will be utilized in the review process.
3. Document edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP 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 Protocol Narrative 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 Narrative and SOPs. Post new versions on the inter-net and forward copies to all individuals with a previous version of the affected Protocol Narrative or SOP.

Central Alaska Network

Moose Protocol

Supplementary Material A – Example Data file for Geo-Spatial Analysis

Please use the following web link for the Central Alaska Network website to access the example Excel spreadsheet:

<http://www1.nature.nps.gov/im/units/cakn/Monitoring.htm>

A Spatial Moose Survey Estimation Method

Introduction

This is an introduction to a spatial moose survey estimation method. The significant changes from previous moose survey methods are the sample unit layout design and the data analysis method. The spatial method uses newer technologies to greater advantage, including GPS (Global Positioning System), GIS (Geographic Information System), and a spatial statistics analysis method. It is hoped that this method will be easier to implement and more cost effective than previous methods.

Methods

Overview

The SPATIAL method involves five basic elements that include, 1) defining the survey area, 2) stratifying the area, 3) determining sample sizes, 4) surveying a random sample of units within the area, and 5) analyzing the data. Major changes from the traditional stratified random sample method (Gasaway et al.) are: the size of the survey area can be much larger, sample units have boundaries that are blocks delineated by latitude and longitude, elimination of the sightability correction factor plots, and the analysis utilizes ARCINFO (ERSI Redlands, Ca) GIS and a spatial statistics model. It is important to note that the survey data collected can still be analyzed using MOOSEPOP.

Sample Units

One of the major departures from earlier methods is the sample unit. Earlier methods defined sample units with borders based on landmarks including roads, trails, rivers, creeks, ridges, old firelines, and treelines. The spatial method utilizes GIS technology to layout the sample units. The north-south boundaries are based on even increments of latitude (2 minutes, starting at 0) and the east-west boundaries are based on increments of longitude (5 minutes, starting at 0). At approximately 65 degrees latitude sample unit size is approximately 5.5 square miles.

Area

The initial step in doing the spatial method is to identify the survey area. The size of the survey area can be quite large (one was 5000 mi²). Identification of the survey area is enhanced using GIS technology. Sample units on a 2 degree latitude by 5 degree longitude grid, as described earlier, have been produced for the whole state of Alaska and the Yukon territory. Parts of this grid can be overlaid on 1:250,000 USGS topographic maps in a GIS. Then, by using the select feature from a GIS, the sample units to comprise a survey are easily selected. Finally, a database (or EXCEL file) of the sample units comprising the survey area is easily created.

Maps and data forms are used for stratification and sampling. Sample units are overlaid on a 1:250,000 scale USGS maps for navigation purposes, and on the back a bare outline of sample units is given that gives information on the latitude and longitude of each sample unit. The numbers listed below each sample unit are something like 6208-16220, which means that the southeast corner of that sample unit is at the coordinates 62 degrees, 08 minute north latitude, and 162 degrees, 20 minutes west longitude. The copies were then laminated with plastic to make them durable for multiple use. Laminated maps can be written on with permanent markers (sharpie Brand) and then be wiped clean using isopropyl alcohol (rubbing) and a rag, and then reused to following day. Several sets of maps are produced so each survey crew can have a complete set to use during survey sampling.

Data Entry

All data, including stratification and actual counts, should be entered into the EXCEL files that are provided with the maps.

Stratification

The first step in conducting the survey is to complete the stratification. This involves flying transects through the middle of each sample unit and classifying it to a relative moose density and habitat. Flying down the center of the sample unit allows about 50 units to be stratified per hour, and it is common to do about 250 sample units per day or about 1250 mi² per day, depending on day length and travel time to and from the survey area.

The next step in conducting the survey is to complete the stratification. This can be done in one of several ways. A flight may be taken just prior to a survey where local abundance of moose is established. This often allows 3 or 4 strata to be distinguished (e.g., very high, high, medium, and low abundance). This provides the most accurate stratification but may change rapidly, so it requires surveying the area immediately after stratification. This is a dynamic stratification.

Other ways to stratify are based on habitat and past experience. The sample units using the spatial technique are about ½ the size of those using the traditional Gasaway method, and hence movement can be a greater problem. So instead of trying to stratify where the moose are during the flight, groups of plots are considered together based on sightings, tracks, and habitat. Stratification then involves "painting with a broad brush" to classify groups of samples. This uses a combination of the number of observed moose, observed tracks, and the related habitat for stratifying. For example, even if you don't actually observe a moose (or many moose) in a sample unit, but others nearby of substantially the same habitat type do have moose, you should stratify it similarly as those nearby because it has a high probability of being used by moose at the time of the survey. This stratification is static, and can be used, with slight modification, year after year. The

static stratification is less precise than the dynamic one. Because intimate knowledge of sample units is lacking, there are often only 2 strata (e.g., high and low). Also, because the stratification is static, sampling can occur over the course of several weeks rather than several days. Another possibility is a hybrid strategy where sample units that are clearly within a strata are initially determined, and then a quick flight with a fast airplane can be used to stratify sample units that are uncertain.

Personnel requirement in the airplane, excluding the pilot, are 1 navigator/notetaker, and 2 observers. Stratification can be done in many ways, including a consensus where, after each sample unit is passed over and the pilot calls out the new border, the Navigator/notetaker calls out a classification and the two observers either confer or rebut that classification. Alternatively, the navigator/notetaker can be responsible for making the call. It is also important to use local expert knowledge, previous stratifications, and any other sources of information to make the best stratification possible. It is also possible to stratify the area based only on previous information – without having to fly.

Stratifying can be done to as many levels as desired. However, if the stratification is being done from the office, and/or the same stratification will be used from year to year, then it will be difficult to stratify into anything more than low and high. The criteria for determining the breaks in stratification depend on the study area and they are relative. In general, try to get about 30-40 percent of the sample units classified as high, and 60-70 percent as low.

The main reason for stratification is to allocate sample units. It is desirable to isolate variability. In general, we need to sample a higher proportion of sample units with higher abundance of moose because they usually have higher variability.

Selecting Survey Samples

Once the stratification data have been entered, the EXCEL file should be sorted first by stratification, and then by the random order column. Sample units for the supercubs are then taken from the top of the list for each stratum. Usually, the total number is selected so that each supercub can have 12 sample units. After all sample units are identified for the day, they are grouped into areas so that supercubs can fly them efficiently and to minimize contact with other aircraft. In general, about 100 sample units should be flown in all, with no less than 25 in any strata. When the survey is nearly complete, about 10 sample units may be used nonrandomly to fill in any areas that were not sampled, or had light coverage, due to random sampling. This is important for the spatial statistics analytical method, which does not rely on the fact that the data are chosen as random.

Conducting the survey

Flying the sample units uses GPS technology. The latitude and longitude of the southeast corner of each sample unit was used to identify the sample units. Using a GPS and the rectangular sample units obviates the need for detailed maps. Several methods may be used to fly the sample units. One method is to fly transects from one end of the sample

unit to the other, and then move incrementally through the plot on each transect. This is efficient and works well in flat terrain. However, it is difficult in mountainous terrain. In mountainous terrain, it is more efficient to fly contours without paying close attention to the boundaries, only ensuring that all of the sample unit is covered. Then, if a moose is found near a border, the position can be recorded as a waypoint and the GPS can be used to decide whether it is in or out of the sample unit.

The samples should be flown at a rate of about 8 minutes per square mile, so it may take 30-50 minutes to do a sample unit. The rate can vary depending on the sightability and tracking conditions. If there is deep snow and it is more than several days old, and there are no tracks, then the time can be cut down somewhat if it is certain there are no moose. Likewise, if there is little vegetation so that sightability is excellent, then the time can be shortened. Conversely, if there is dense tree cover, samples should be flown at 12 minutes per square mile. In general, a supercub can do from 6 to 12 units per day depending on conditions and day length. If a supercub has 2 or 3 adjacent sample units, they can be flown concurrently. Whenever a moose is encountered, it can be simply determined which sample unit it belongs in by using the GPS.

Comparison to other methods

Stratified Random Sampling

The first widely-used statistically-based method for surveying moose was a stratified random sampling design (Gasaway et al., 1987). In this method, stratification was achieved by using 3 observers and a pilot in an airplane (such as a Cessna 185) that flew at about 100 knots and surveyed at a rate of about 100 mi² per hour. Sample units were observed just prior to sampling to determine relative abundance of moose so that sample units could be stratified. After stratification, the sample units were flown as quickly as possible while the stratification was still good. Sample units were about 10-15 mi² in size, and flown with small aircraft (such as a Piper SuperCub) at slow speed (about 70 mph) at about 4 minutes per square mile. After a sample unit had been flown, a smaller area within the sample unit, of about 2 mi², was flown at an intensity of about 12 minutes per square mile to determine how many moose had been missed in the first sampling. This second, more intensive flight, provided the basis of a sightability correction factor (SCF) that adjusted the estimates upwards according to the proportion of moose that were missed during the initial sampling of a unit.