Aerial Ungulate Survey Protocol Manual

Alberta Sustainable Resource Development
Fish and Wildlife Division
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INTRODUCTION

Aerial surveys are the primary method used to assess the population size, distribution, population trends and herd composition of ungulates in Alberta. These pieces of information are crucial to the effective management and conservation of ungulates, and are used by Alberta Sustainable Resource Development (ASRD) to set hunting licence allocations, identify areas with agricultural depredation problems, and determine priority areas for recovery actions. Aerial surveys of ungulates have a long history in Alberta, and have continuously evolved to take advantage of new analytical techniques, aircraft, and knowledge of the abundance and distribution of ungulate species.

Currently, aerial surveys are used to monitor all species of ungulates in the province, including white-tailed and mule deer, moose, elk, bison, caribou, pronghorn antelope, mountain goats, and bighorn sheep.

This document is intended to serve as a reference for biologists conducting aerial surveys for ungulates in Alberta, and in conjunction with supplementary materials provided in the D-AUS Safety Protocol (ACA and ASRD, 2008), to combine all relevant protocols on aerial survey approaches into a single source. Because aerial survey approaches are likely to continually evolve, this document will be updated periodically to ensure that it describes the most current techniques used to survey ungulates in Alberta.
SURVEY PLANNING

Identifying Information Needs and Survey Objectives
As in all jurisdictions, the need for aerial ungulate surveys in Alberta far outweighs allocated funding, requiring that only areas and species with the highest priorities are surveyed in any given year. Establishing survey priorities is a province-wide process that incorporates the management objectives for individual species, weather conditions and winter severity, disease outbreaks, sensitivity of ungulates to human disturbance or harvest, public interest and expense of surveying. Every year, many areas or species remain unsurveyed simply because higher priorities have been identified. In many cases, this also means that cost-effective survey approaches are selected over methods that may provide more rigorous population estimates. This approach ensures that the basic information required for management is collected while allowing additional areas or species to be surveyed.

ASRD headquarters staff from the Wildlife Management Branch of the Fish and Wildlife Division, determines annual provincial aerial survey priorities based on a 3-year rotational plan. Rotational plans are developed based on input from area staff across the province. Many trend surveys are conducted on a rigid rotational basis to ensure that surveys are conducted frequently enough to provide regular abundance measures, which are critical for the effective interpretation of these types of surveys. Some species, such as pronghorn antelope and mountain goats, are sensitive to harvest and/or winter severity and frequent surveys are essential to effectively manage human harvest and prevent population declines. Other species, such as moose and deer, are surveyed in response to area-specific management needs; areas that are intensively managed for high harvest levels are typically surveyed much more frequently than areas that are managed less intensively. In addition, the presence of heavy forest cover that results in low sightability prevents the implementation of surveys for moose in some WMUs, and for deer in the majority of the foothills and mountain units. The following criteria for establishing survey priorities was adapted from Bisset and McLaren (1999), and describes the procedures used to allocate limited aerial ungulate survey funding in Alberta:

1. Length of time since previous survey.
2. WMUs in which the target ungulate herd has been declining over previous surveys or in which there are indications from other information (harvest surveys), that the population may be declining.

3. Location of the WMU: WMUs located in core target species range should have high priority.

4. Hunting pressure: WMUs with heaviest hunting pressure should have high priority

5. WMUs that are below ASRD objectives or population potential.

6. WMUs scheduled for a survey in the previous year but were not done for logistical reasons.

7. WMUs of special interest, including that are the subject of ongoing research, where high potential for disease exists (e.g., CWD) or which overlap with the ranges of species of concern (e.g., caribou).

Determining the objectives of an ungulate survey is the first step in implementation, and precludes budgeting, allocating staff resources, or any other planning. The highest priority in establishing survey objectives is to ensure that management and conservation needs are addressed. There is little to be gained by a survey that enumerates a population parameter that is not helpful for management, or that results in population estimates that are too crude to allow a confident assessment of the herd’s status. Survey leaders should carefully assess the type of information needed on an ungulate population, and ensure that all subsequent planning and budgeting will result in the collection of these data. In some cases, for example, only herd sex and age ratios may be necessary for management; these types of surveys are typically much more economical to implement than those that result in population estimates. In many circumstances, however, the additional cost imposed by conducting a slightly more rigorous survey design, or by collecting population data on additional species in the survey area, is worth the added expense. These factors should be considered by both area staff and provincial-level planners during the allocation of survey funding.
Survey Timing

Aerial ungulate surveys should be timed to maximize animal sightability, maximize the usefulness of population estimates for resource managers, minimize the stress imposed on the animals due to harassment by the survey aircraft, and avoid negative effects on members of the public that are enjoying the resource. For most species, aerial surveys are best conducted during winter months (December-March) when snowfall improves sightability, hunting seasons are not open, and population estimates can be developed in time to allocate hunting tags for the following fall seasons (Table 1). Surveys for Pronghorn Antelope and Mountain Goats are best performed during summer when the pelage of these species contrasts with their habitats. In addition, surveys for these species during summer provide demographic and population data immediately prior to fall hunting seasons and after winter mortality, providing timely information for setting tag allocations.

In addition to basic time-of-year considerations, aerial surveys must be conducted when weather conditions allow safe aircraft operation and provide adequate sightability. For example, Allen (2005) recommended conducting elk surveys during periods of flat light and high snow cover, in order to maximize sightability of elk groups. Most importantly, surveys which do not directly correct for sightability bias must be conducted during consistent weather conditions across years in order to allow reasonable comparisons between population estimates. Therefore, surveys should be conducted during periods of high snow cover. This means initiating surveys during weather conditions that are forecasted to be consistent when high snow cover is present. Deteriorating snow conditions during the course of a survey, for example, could result in declining sightability and reduce both the precision and accuracy of final population estimates. In some areas of the province, such as the Pincher Creek and Lethbridge areas, the rarity of good snow conditions may necessitate that surveys are conducted during periods of consistent weather without high snow cover. While sightability during these surveys will likely be lower than if they were conducted with abundant snow cover, population estimates will be more comparable between years and it is not necessary to wait for relatively rare snowfall events, which may not occur at all during some years.

In all cases, surveys should occur only when weather conditions allow safe aircraft operation; factors such as high wind and/or cloud cover not only reduce the safety of the surveys, but compromise sightability and can lead to observer fatigue as well. Survey
participants should rely on pilot judgment as well as their own experiences and comfort level to determine when survey flights should occur or be prematurely terminated.

For some species, surveys should occur at specific times of day in order to maximize sightability or reduce the risk of heat stress. Mountain goats, for example, should be surveyed only during the morning and evening hours when they are most active; surveying during mid-day may also subject the animals to unnecessary stress due to high temperatures. Surveys for most species, however, can occur at any time of day when light conditions are adequate for observing animals.
Table 1. Geographic locations, survey objectives, survey types, and time of year when aerial surveys should be conducted for ungulates in Alberta.

<table>
<thead>
<tr>
<th>Species</th>
<th>Zone</th>
<th>Survey Objective&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Survey Method&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Survey Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bison</td>
<td>Boreal</td>
<td>D, A, C</td>
<td>TC</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>Mountain Goat</td>
<td>Mountains</td>
<td>D, A, C</td>
<td>TC</td>
<td>July</td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>Mountains</td>
<td>D, A, C</td>
<td>TC</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>Moose</td>
<td>Prairies, Parkland, Boreal, Foothills, Mountains</td>
<td>A, C</td>
<td>SRB</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>Elk</td>
<td>Prairies, Parkland, Boreal, Foothills, Mountains</td>
<td>D, A, C</td>
<td>TC, SRB</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>White-tailed Deer</td>
<td>Prairies, Parkland</td>
<td>A, C</td>
<td>SRB</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>Mule Deer</td>
<td>Prairies, Parkland</td>
<td>A, C</td>
<td>SRB</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>Caribou</td>
<td>Boreal, Mountains</td>
<td>C</td>
<td>C</td>
<td>Jan-Mar</td>
</tr>
<tr>
<td>Pronghorn Antelope</td>
<td>Prairies</td>
<td>A, C</td>
<td>LT</td>
<td>July</td>
</tr>
</tbody>
</table>

<sup>1</sup> D=distribution; A=abundance and/or density; C=sex and/or age composition

<sup>2</sup> TC= total count; SRB=stratified random block; C=composition; LT=line-transect
Budgeting Staff and Resources

Establishing budgets for aerial ungulate surveys requires that careful thought be focused on the objectives of the survey. Aircraft expenses typically represent the vast majority of an overall survey budget, however adequate funding and staff time must also be budgeted to ensure that the planning, data analysis, and reporting can be completed and that provincial deadlines for these activities are met.

Investing substantial time into the planning phase of an aerial survey can often result in large dividends in data quality, while simultaneously reducing overall survey costs. Allocating adequate time to stratifying sampling units, for example, can increase the precision of population estimates while reducing the number of units that must be flown. In addition, the use of staff time to plan and place fuel caches and carefully map flight routes can often result in substantial reductions in survey costs. While survey leaders should ensure that enough funding is budgeted for each survey to ensure that all survey objectives can be met, every effort should be made to complete the survey under budget as this allows allocation of funding to other surveys, ultimately improving wildlife management programs within the province.

In some areas of the province, the relative rarity of good survey conditions may mean that several surveys must be conducted simultaneously; survey leaders in these areas should ensure that adequate staff is available to complete all surveys when weather conditions become favorable. Survey leaders should request assistance from experienced staff in other areas when necessary.

Personnel

Surveys should be planned and implemented by staff experienced with surveying the target species in the area of interest. In addition to safety, maximizing the quality of the data collected while simultaneously minimizing stress to the animals should be the primary goals of every survey; this requires that experienced personnel are involved with all aspects of survey planning and delivery. Under some circumstances, this may necessitate collaborating with staff from other regions, hiring former staff members on a contract basis to assist with the survey, or consulting with experts to ensure that the survey design is adequate. Planning the logistics of surveys may also necessitate close collaboration with the aircraft company and/or pilot contracted for the flying, as they
often have expert knowledge on the weather and terrain conditions that may affect the survey, the location of fuel caches, and other important logistical considerations.

During survey flights, observers should have extensive experience conducting surveys for the species of interest. Gasaway et al. (1986) found that inexperienced observers missed considerably more moose as experienced staff. Inexperienced observers may also make substantially more errors in identifying animals, often resulting in circling of ‘stump moose’, for example. This not only decreases the efficiency of the survey, but can unnecessarily increase observer fatigue and risk. Perhaps most importantly, inexperienced observers often have difficulty in accurately classifying animals into proper age and sex classes, which may result in errors in final age and sex ratios or subject the surveyed animals to unnecessary stress due to increased harassment from the survey aircraft during classification attempts. Therefore, inexperienced observers should be limited to 1 per aircraft, and sit on the same side of the aircraft as a highly experienced observer who can aid in herd classification and provide training to the new observer. In addition, integrating inexperienced observers into survey flights should be conducted only as part of long-term staff development and mentoring strategies; most aerial surveys are not an appropriate mechanism to introduce members of the public or non-essential personnel to wildlife population data collection. Similarly, survey staff should recognize the need to train new observers for (ideally) several years prior to the retirement or departure of key staff, and to ensure that enough experienced observers are available to conduct all surveys when conditions are favorable.

Basic duties for personnel participating in aerial ungulate surveys are as follows:

**Pilot**
- Responsible for safety decisions
- Monitors weather conditions
- Monitors in-flight hazards
- Follows flight lines
- Navigates to survey areas
- May assist with observing
- Responds to observer requests to pursue animals, circle, or hover

**Lead Observer**
• Ultimately responsible to determine whether flights should begin or continue
• Responsible for safety decisions
• Monitors weather conditions
• Monitors in-flight hazards
• Ensures pilot is following flight lines
• Ensures flight paths are efficient
• Helps pilot navigate to survey areas
• May assist with observing
• Determines whether animals are within sample unit boundaries
• Typically records data
• Responsible for quality of data collection

Secondary Observers
• Scans for target wildlife species
• Counts herd sizes of target wildlife species
• Classifies target wildlife species by sex and age
• Reports all observations to lead observer
• Reports in flight hazards if observed

Observer Fatigue
Surveys should be conducted to ensure that observers do not experience excess fatigue, which may affect their ability to observe wildlife and/or record accurate data. In most cases, aircraft should land at least once every 3 hours to allow the survey crew and pilot to rest their eyes, stretch, and recover from motion sickness, if necessary. Work in Wyoming has shown that an observer’s ability to sight wildlife deteriorates after 3 hours; the number of flights exceeding this time should be minimized. While the relatively short flight duration of helicopters ensures regular landing for refueling, these short breaks are not adequate to allow observers to fully recover from observer fatigue. Whenever possible, total daily flight duration should not exceed 6 hours, and a mid-day break of at least 2 hours should be scheduled in order to ensure observers continue to operate effectively. Pressure to complete a survey within a specific timeframe should not outweigh data quality, which can be significantly impacted by observer fatigue.

Pilots
Surveying wildlife is unique from most other types of aircraft operation, often requiring low-level circling, flying at low speeds, maintaining consistent speeds and heights above ground, following rigid transect lines, and pursuing or herding of wildlife to allow herd counts and classification. Whenever possible, all pilots participating in aerial surveys of ungulates should have extensive experience flying in the survey area and have conducted similar types of flying to that required during the survey. Pilots should also operate in a manner that minimizes observer fatigue and motion-sickness; aggressive maneuvers are not necessary for wildlife surveys and can actually reduce the efficiency of data collection by subjecting observers to unnecessary physical stress.

Pilots should have an interest in the survey design and a demonstrated commitment to safe flight operations. Ideally, survey staff should establish long-term relationships with local aircraft companies and individual pilots to conduct surveys within their region. Using local companies provides many advantages over using pilots and aircraft from other areas, including expert knowledge of the survey area, company-established fuel caches, and reduced shuttle time and travel-related expenditures. In many cases, total survey budgets are lower when local aircraft are used even if their hourly rates are substantially higher than other companies.

At a minimum, aircraft pilots should meet the following requirements:

**Rotor wing** – Pilots within 100 hours of the minimum requirement (except the mountain flying time) may be used under emergency situations.

- 600 hours total rotor wing flight time,
- Minimum 300 hours pilot in command of rotor wing aircraft,
- Current Canadian Commercial Pilot License for rotor wing,
- Current Pilot Proficiency Check (PPC),
- When flying in mountainous terrain, must have had 100 hours as pilot in command of rotor wing aircraft during low level mountain flying and;
- Transport Canada recognized mountain-flying course when flying in mountainous terrain.
- Experience flying aerial surveys

**Fixed Wing** – Pilots within 100 hours of the minimum requirement (except the mountain flying time) may be used under emergency situations.
• 600 hours total fixed wing flying time,
• 200 hours pilot in command of fixed wing aircraft,
• Current Pilot Proficiency Check (PPC),
• Current Commercial Pilots License
• Proficient in operating out of short length, grass and gravel strips
• When flying in mountainous terrain, must have had 100 hours as pilot in command of fixed wing aircraft during low level mountain flying and;
• Transport Canada recognized mountain-flying course when flying in mountainous terrain.
• Experience flying aerial surveys

Aircraft
Aerial surveys necessitate the use of aircraft that can operate safely at low speeds and altitudes, offer excellent forward and side-visibility, can carry 1-3 passengers, and have fuel capacities large enough to meet survey goals. In Alberta, virtually all surveys that rely on rotary-wing aircraft make use of the Bell 206 Jetranger (B model) or Longranger (L model) helicopters, fitted with bubble windows in the rear seats. The Bell 206 has a proven safety record, can carry 3 passengers plus their gear, is economical as compared to other turbine-engine helicopters, and is widely available. In order to maintain consistent sightability between years, all surveys in the province should utilize the Bell 206, whenever possible. While other helicopters such as the Hughes 500 have similar performance characteristics, they have not been as widely used and their use may make survey results incomparable to previous years due to differences in sightability between aircraft.

Fixed-wing aircraft are rarely used for the intensive portion of aerial surveys in Alberta; therefore, maintaining consistent sightability across years is not critical to effective survey implementation. This allows more flexibility in the selection of aircraft; in addition, many models have similar characteristics and may be used essentially interchangeably. However, fixed-wing aircraft must meet several criteria in order to allow the safe and accurate collection of stratification data. Most importantly, planes must be powerful enough and have stall speeds slow enough to allow safe operation at slow speeds, low altitude, and in undulating terrain. These aircraft should also have a high-mount wing, which allows side-observation. The most common fixed-wing aircraft used in aerial ungulate surveys in Alberta include the Cessna 180, 182, 185, and 206;
these aircraft have stall speeds below 100 kph, have seating for the pilot plus 3 observers, and can carry fuel for adequate flight range. In addition, these aircraft are often available with skis during winter and can operate out of primitive airstrips, which may be necessary during some surveys. The Piper PA-18 Supercub, Maule M-7, Aviat Husky, and Bellanca Scout are proven bush-type aircraft with excellent performance characteristics, superior rear-seat observability, and extremely slow stall speeds, however they are limited to carrying only 1 passenger and therefore of more limited utility for pre-stratification flights.

In addition to standard safety equipment required by Transport Canada, aircraft should meet the following criteria when used for aerial ungulate surveys:

- Transport Canada approved VHF-AM transceiver covering the 118.0 – 139.0 MHz frequency range, with push to talk on the cyclic stick (rotary wing) or yoke (fixed wing),
- Transport Canada approved VHF-FM transceiver (equivalent to the Technosonic TFM138B) capable of operating on 150.0 – 174.0 transmit-and-receive, with a selectable audible tone option, and capable of narrow banding,
- Intercom communications with a minimum of one voice-activated headset per seat
- Hobbs meter (installed on the collective column in rotary wing) that is activated when aircraft is in flight or during full power ground hovers. Hour meter calibrated to show readings in hours and tenths of hours. When specialty or out of province rotor wing without Hobbs meters are hired, a method of determining accurate flight time, such as audited pilot log books or helibase manager records, must be used for billing,
- Global Positioning System (GPS) unit, with degree decimal minute (DMD) as the standard display
- Near real time tracking device that is capable of providing position, speed and heading in a standard Aircraft Flight Following (AFF) format at a minimum of every 5 minutes.
- Rotary wings must have bubble-type windows in the rear
- Portable fuel pump, and
- Shoulder harness for all seats
**Navigation**

The lead observer (seated in the left-front seat in most helicopters and the right-front seat in most fixed-wing aircraft) is responsible for ensuring that the survey proceeds in an efficient manner, dead-head time is minimized, all SUs are searched at the appropriate speed and height above ground, and that search patterns follow provincial standards. The lead observer is also responsible for determining whether sighted animals fall within survey unit boundaries, and in most cases, also records all survey data, including the location of ungulate groups.

In most cases, the lead observer will rely on a GPS unit (a separate unit from the pilot’s GPS) and topographic maps of the study area and/or shapefiles loaded onto the GPS unit. The lead observer should discuss the basic flight route and survey plan with the pilot prior to the initiation of each survey day, to ensure that minimal time is spent dead-heading to and from SUs and fuel caches. The lead observer may also utilize a GPS unit linked to a laptop computer with GIS software installed; this allows real-time tracking of the aircraft position in relation to survey unit boundaries and may allow more efficient use of aircraft time than maps and a GPS alone. Recording the survey flight route on an on-board computer also helps to ensure that no survey areas are missed or surveyed more than once. Diligent use of a GPS unit, particularly those with mapping capabilities, can be used in place of an on-board computer, and have the added advantage of being less prone to software problems and tend to function more reliably during cold weather.

**Data Recording**

After safety and basic study design, recording accurate, quality data is the most important aspect of implementing aerial ungulate surveys. Data recorders must ensure that all data necessary for the analysis and interpretation of survey results are recorded legibly and in a manner that allows use by staff that were not present on the survey flight, or may use the data in the future and may not understand aspects of the survey that seem obvious to survey crew members. Currently, standardized survey data forms are not utilized in Alberta, however all surveys must record the following data:

- Date
- Flight start and stop times
- Personnel
- Weather (including temperature and wind speed and direction)
In cases where sightability correction models are to be used in conjunction with SRB surveys, variables that are part of the sightability model, such as percent tree cover and percent snow cover, must also be recorded. In addition, all sightings of rare or threatened species (such as sightings of caribou during moose surveys) or other observations of interest should be recorded as long as the survey for the target species is not compromised. Sightings of additional wildlife species which are threatened or endangered species are to be recorded separately in the ASRD Fisheries and Wildlife Management Information System (FWMIS) data base. A UTM coordinate and description of these sightings should be recorded.

**Equipment**

**Survey Equipment**

- Topographic Maps
- GPS with map capabilities, loaded with shapefiles of the survey area (example: sheep winter ranges; survey blocks) and major landscape features to aid in navigation
- Spare GPS batteries
- Clipboards
- Survey data sheets
- Number 2 lead pencils
- Binoculars

**Personal Equipment**

- Appropriate clothing (includes coveralls, snow pants, winter gloves and toque) and footwear suitable for spending a night in severe weather conditions at the time or location of the survey. Outer clothing should be dark to minimize reflection on aircraft windows.
☐ CSA approved footwear if participating in refuelling, transporting fuel, or assisting pilots with moving aircraft (e.g. moving helicopter into hangar).
☐ Safety glasses to wear when outside of the aircraft
☐ Polarized sunglasses to reduce glare (amber tint may be valuable for overcast days)
☐ Ear protection (headsets are usually provided by pilot)
☐ Anti-nausea medication (if required), to be provided by the individual
☐ A brimmed hat to provide protection from direct sunlight. Hats without a button on the top provide the least discomfort from headsets
☐ Adequate food and liquid for the day

Safety

Safety is the #1 consideration during all aerial surveys, greatly exceeding the need to collect data. Safety protocol for aerial surveys in Alberta exceed the scope of this document, however all survey staff should consult and be familiar with the safety procedures outlined in the Delegated Aerial Ungulate Survey Safety Protocol.
STRATIFIED RANDOM BLOCK SURVEYS

When possible, Alberta strives to implement aerial survey approaches that allow statistically rigorous estimates of ungulate population numbers and density within WMUs. In most cases, this means using the ‘Gasaway Method’ (Gasaway et al. 1986) to design and implement counts in a random selection of survey blocks within WMUs. This approach sees widespread application for moose and deer in areas where the forest cover is low enough to allow good sightability. In addition to allowing precise population estimates, this approach often allows estimates of male / female / young ratios, as well as the relative number of small, medium, and large-antlered males if surveys are conducted prior to antler drop.

Conducting stratified random block surveys includes dividing a WMU or group of adjacent WMUs into several dozen smaller sampling units (SUs) that are approximately equal in size, and then classifying each SU into a stratum that describes the relative number of animals of the species of interest that are expected to be present within that block. SUs vary in size depending on the size of the WMU and density of the target species; SUs for moose in northern Alberta are typically 5 minutes latitude X 5 minutes longitude, for example, while SUs for deer surveys in southern Alberta are often 3 minutes latitude X 5 minutes longitude. Stratification of SUs can be based on observations from fixed-wing aircraft immediately prior to the intensive portion of the survey, previous knowledge of ungulate distribution within the WMU, or habitat features within each survey block. Following stratification, a portion of the SUs within each stratum are randomly selected for intensive searching via rotary-winged aircraft (helicopter). During surveys, each block is thoroughly searched and observers classify each animal into standardized sex and age categories (see Tables 2-4). A series of calculations allow the number of animals seen in the sample of survey blocks to be converted to a population estimate for the entire WMU as well as an error associated with the estimate; additional blocks are surveyed until the error meets provincial standards.

**Stratification**

The stratification of SUs prior to the intensive portion of a SRB survey design is one of the most important components of the survey. Proper stratification can simultaneously
improve the precision of population estimates while reducing aircraft costs, thereby improving the quality of the data as well as making funding available for surveys in other areas or for other species. Much staff time and survey dollars can be wasted with an improper stratification scheme; therefore, survey leaders should expend substantial effort to ensure that the best available information is used to stratify SUs. Sources of information used to stratify a survey area can vary widely, and often the best stratification occurs with the simultaneous use of multiple approaches. In all cases, the goal of stratification is to assign individual units into strata (typically 3 stratum are used: low, medium, and high) that describe the relative number of the target species within the SU. Because animal distribution can change rapidly in response to weather conditions, snow depth, and time of day, the survey leader must consider these factors when selecting a stratification method. In some cases, expert knowledge of the habits of the species within the survey must be relied upon to adjust the stratification classifications of individual SUs.

Stratification Flights – When the distribution of the target species within the survey area is unknown or unpredictable, adequate stratification may only be possible thru stratification flights conducted immediately prior to the initiation of the intensive portion of the survey. In order to reduce overall survey costs, stratification flights should be conducted from single engine, high-wing aircraft such as the Cessna 180, 185, or 206 except in mountainous areas, where rotary-wing aircraft should be used. The survey crew should consist of a pilot, lead observer, and 2 rear-seat observers. Flight lines should be flown either north-south or east-west, as this allows the pilot to follow lines of latitude or longitude and greatly reduces the complexity of navigation. Flight lines are typically 1-minute, however the main goal is to ensure that at least 1 transect is flown across each survey SU, and that survey effort is equal across all survey SUs. Boundary lines of SUs are not flown because observed animals could be in one of two SUs, while only a GPS location on the flight line is recorded. The aircraft speed should be approximately 130-150 km/hour, at an altitude above ground from 60 to 150 metres, depending on the topography and forest cover present within the survey area. Height above ground and aircraft speed can be altered to ensure that overall sightability is approximately equal across SUs. The lead observer should record the number of animals of the species of interest observed within each SU. No attempts should be made to classify animals during stratification flights, nor should the pilot circle on groups of
animals to obtain precise counts. Animal sign, such as fresh moose tracks, should also be recorded as an observation for the purposes of stratification. Oswald (1998) outlines criteria to distinguish tracks of target ungulate species (Figure 1, 2). Typically, observers should scan from ¼ to ½ mile out from the aircraft, depending on habitat conditions. The goal of stratification flights it to coarsely describe animal distribution as cost-effectively as possible.

In order to ensure that animal distribution does not change substantially between the pre-stratification flights and the completion of the intensive portion of the survey, pre-stratification flights should occur during periods when weather patterns are consistent. Rapidly changing temperatures and snow-depth, for example, can result in drastic changes in ungulate distribution during a survey, effectively reducing the utility of stratification and reducing the precision of population estimates.

Resource Selection Models (RSMs)– When quality GPS location data are available for a species of interest within a survey unit, or within nearby units with similar habitat conditions, the development of Resource Selection Models (RSMs) can allow stratification of subunits without the need for prestratification flights (Manly 2002, Allen 2005).

RSMs are a spatially explicit prediction of animal distribution that are based on observed habitat-use patterns. These models typically take one of two forms: Resource Selection Functions (RSFs), which are proportional to the probability of animal use of an area, and Resource Selection Probability Functions (RSPFs), which represent the true probability of animal use of an area. RSFs are derived from locations known to have been used by a member of the species of interest (used locations) and random locations within the same area (available locations); RSPFs are developed with used locations and locations where the species is known not to exist (unused locations). RSMs can provide a good measure of approximate animal distribution and may be useful for aerial surveys if developed at the appropriate scale. For example, Allen (2005) found that a RSF developed from elk GPS collar location data and random locations in the same landscape was superior to tree-cover measures to stratify SUs for elk.
Decisions to use RSMs to stratify a survey unit should consider the quality and quantity of the data used to develop the model, the spatial scale of the model, the proximity of the data used to generate the model to the area requiring stratification, variability in

Figure 1. Diagrams of commonly sighted tracks encountered during aerial ungulate surveys in Alberta. From Oswald (1998).
Figure 2. Diagrams of old and fresh moose tracks. From Oswald (1998).
animal distribution due to habitat features and weather patterns, survey budgets, and if possible, a direct comparison of the RSM approach to other stratification methods using past aerial survey data from the area of interest.

Ideally, animal location data used to generate RSMs for survey stratification should be unbiased with respect to the age and sex of the animals, and should be collected within the unit to be surveyed, during the time of year, times of day, and weather conditions during which surveys are likely to occur. For example, GPS collar location data from an intensive moose study should be rarified to include only those data from winter months (January-March) during daylight hours, and during periods of excellent snow coverage. Extra caution is also warranted if habitat bias in the acquisition success of location data is apparent, as might be the case with data collected either during past aerial surveys or with some GPS collar systems (Frair et al. 2004). If the sex and/or age of animals collared are not representative of the population as a whole, expert knowledge should be used to determine the potential impact of this bias on the ability of a RSM to describe the distribution of the population. In ungulate telemetry studies it is very common to radiocollar only adult female members of the population; this may have negligible impacts on the ability of a resulting RSM to predict the spatial distribution of the overall population if other sex and age classes exhibit similar habitat use patterns, but could have major implications when this is not the case. Location data should also be recent, or corrections must be made in the RSM predictions to account for landscape changes that have occurred since the collection of the animal location data.

Ideally, an RSM used to stratify a unit for aerial surveys should predict animal distribution at a spatial scale no larger than the size of the SUs in the survey. Coarse RSMs make it impossible to adequately delineate between low, medium, or high strata at the scale of the SU, while finer-scale models can always be summarized at the scale of the SU. When possible, RSMs should be developed with animal location data that was collected within the WMU to be surveyed. The increasing prevalence of the use of GPS radiocollars in ungulate population studies makes this feasible in many areas. Indeed, it may be more cost-effective to radiocollar and monitor a sample of ungulates within a series of adjacent WMUs than to conduct pre-stratification flights prior to every survey. When high-quality location data are not available, it may be possible to use location data from past aerial surveys within the survey unit if these data were collected accurately. In many cases, animal location data during surveys may consist of only rough
coordinates from maps; these data may not be useful for developing RSMs if the survey unit is highly heterogeneous.

Habitat Maps (Woodlot Data) – In certain areas of the province, basic habitat inventory maps can be used to adequately stratify SUs. These maps are especially useful in areas where ungulates exhibit a strong response to factors such as forest cover, forest-agriculture interface, or prairie/parkland habitats with relatively small amounts of shrub- or forest-cover. In these cases, ungulate distribution may be accurately predicted based only on coarse habitat types.

Expert Knowledge – Whenever possible, survey staff should utilize expert local knowledge to adjust stratification classifications for individual SUs. Knowledge of the locations of ungulate herds, agricultural depredation, or specific habitat conditions (such as low snow-depth on south-facing slopes) can greatly increase the accuracy of stratification, resulting in measurable improvements in the precision of the population estimate. Consultation with Fish and Wildlife Officers, trappers, outfitters, industry workers, landowners, and/or local residents should be undertaken as close to date of the initiation of the survey as possible. Reviewing maps of the survey area with these individuals and changing stratification classifications of individual SUs is a valuable step even when pre-stratification flights are used.

Allocating SUs to Strata- Following pre-stratification flights, use of RSM’s, or other sources of information, each survey SU should be classified into a strata (typically, Low, Medium and High stratum are used, although 2-, 4-, or 5-strata systems are also possible). For pre-stratification flights, the density of animals in each SU is used for categorization. For RSM’s the average value across each survey unit is used, while average % cover is used for coarser habitat maps. Lynch (1997) recommended allocating approximately 20% of SUs to the high strata, 20% to the low strata, and 60% to the medium strata. Allen (2005) found that when using an RSF for post-stratification, the use of natural breaks (Jenks optimization) to classify SUs into strata resulted in much greater precision in population estimates than either the equal allocation approach, or the 20:60:20 approach. Therefore, the Jenks optimization (available in ArcGIS) should be used to allocate SUs to strata, when possible. The strata of individual survey SUs can be altered via expert knowledge following the initial stratification by the Jenks method.
Selecting Units to Survey
During stratified random block surveys, a minimum of 5 SUs from each strata should be randomly selected, without replacement, to include in the intensive portion of the survey. Additional SUs should be selected from strata with high variance using the optimal allocation procedure described by Gasaway et al. (1986) and Lynch (1997); these unit should be flown until the confidence intervals of the population estimate are within acceptable limits.

Intensive Survey Methods
Search Pattern and Intensity – After using a GPS unit to navigate to a corner of a SU to be flown, the basic survey approach for stratified random block surveys involves flying overlapping parallel lines across the SU in order to ensure complete coverage. Each transect should be spaced according to the sightability conditions in the survey area; survey lines are often spaced further apart in open habitats such as the prairies than in the foothills or boreal forest, for example. Lines should be overlapping, so than animals observed near the edge of a line are visible from the next line. Both altitude and speed should be altered according to terrain, vegetation type, and other factors that influence sightability.

When a group of ungulates is sighted, it should be circled to ensure that all members of the herd are seen, and to allow classification of the age and sex of the animals. Groups of animals can be gently herded to an open area to allow classification, however the survey crew should avoid unnecessary stress caused by pursuing aircraft whenever possible. An accurate GPS location should be recorded at the site where the animals were first observed.

Estimating Numbers Missed
Currently, estimates of sighting probability are generally not used in Alberta to adjust population estimates derived from stratified random block surveys; however several recent and ongoing efforts to incorporate sightability measures into SRB surveys have the potential to significantly enhance the quality of data resulting from these surveys. Allen (2005) for example, updated a sightability model for elk (Unsworth et al. 1994) for use with SRB surveys in the foothills of west-central Alberta, but provincial priority-setting has resulted in the continuation of trend surveys in this area, for which sightability corrections do not exist. Habib and Merrill (in preparation) are currently
following Allen’s (2005) approach to develop sightability models for mule deer and white-tailed deer in the parkland portion of the province, and Peters and Hebblewhite (in preparation) have initiated a project to develop a sightability model for moose in the foothills region.

In addition to sightability models, several ASRD staff have begun to utilize distance sampling (Buckland et al. 2001) in conjunction with moose surveys, which inherently incorporates sightability during calculations of population estimates and confidence intervals. The addition of mark-resight techniques to these efforts has the potential to allow the extension of moose surveys into areas where sighting probabilities are low, such as mountain WMUs.

While these efforts may ultimately be incorporated into Alberta’s AUS program as standard protocols, they are not part of current protocols and should be used in consultation with ASRD Wildlife Management Branch staff.
TREND SURVEYS

Trend surveys are widely used in Alberta for surveying elk, mountain goats, bighorn sheep, and pronghorn antelope. These surveys are conducted as ‘total counts’ on previously identified seasonal ranges or established survey transects. Elk and bighorn sheep trend surveys, for example, are conducted during winter when these species congregate on distinct winter ranges, allowing enumeration of a large portion of the population with a relatively cost-effective survey design. These surveys do not allow the calculation of confidence intervals, and accuracy is often unknown. By regularly conducting these surveys under good sighting conditions, however, they provide useful measures of relative abundance and long-term monitoring of population trends if herd distribution does not change through time.

For trend surveys, survey areas, timing, and weather conditions must be consistent between years. For elk and bighorn sheep, winter ranges have been identified through reconnaissance flights and local knowledge, and these areas are searched on a rotational basis during winter months and during snow conditions that permit good sightability. Pronghorn antelope surveys are conducted on standardized 1-mile wide (1.6 km) transects, which are surveyed each year in July.
COMPOSITION SURVEYS

Composition surveys seek only to gather information on the age and sex structure of ungulate herds. These data provide useful information on recruitment rates (young: adult ratios), and allow assessment of specific management strategies such as trophy management of mule deer or bighorn sheep. In many cases, the composition of ungulate herds is more useful than absolute abundance, or the additional survey effort required to develop reliable abundance estimates is cost-prohibitive.

Composition surveys can be designed in a number of different ways, including random searches, quadrats, transects, and winter range surveys. However, survey leaders must make sure that these surveys are implemented using methods that ensure a random sample of individuals of the target species. Searches of elk winter ranges, for example, may yield biased estimates of sex and age composition if bulls use these areas differentially from cows, as has been suggested from a number of studies. In addition, the tendency of males of many species to travel in smaller groups than females often results in lower sightability of males than females, introducing bias to observed sex ratios. Therefore, results of composition surveys should be interpreted with caution unless survey intensity was high enough to ensure equal sightability among sex and age classes or sightability models were used to correct counts of each population segment. Alternatively, where sightability of different population classes is known, the approach of Samuel et al. (1992) can be used to develop ratio estimates.

Alberta has recently adopted standardized sex and age classifications for all ungulate species in the province (Tables 2 to 4). These classifications should be used for all aerial ungulate surveys in Alberta.
SURVEY STANDARDS

Standards for Accuracy and Precision
In the context of aerial ungulate surveys, accuracy refers to how close the population estimate is to the true population size, while precision corresponds to how close repeated population estimates are to the mean population estimate, or in other words, the amount of variability surrounding the population estimate. All surveys should be conducted in a manner such that final population estimates are as accurate, and where applicable, as precise as possible. However, because there is a direct relationship between survey effort (i.e. the number of SUs searched) and precision, tradeoffs must be made between the quality of population estimates and funding availability.

The primary factor that results in accurate population estimates is ensuring that the survey design enumerates all individuals of the target species within the sampling units that are searched. Therefore, accurate population estimates require an estimate of the proportion of the individuals within the survey area that were missed during flights, or a ‘sightability correction’. In some cases, sightability corrections may be negligible due to a high probability of observing an individual of the target species, as may be the case in open habitats, where herd sizes are large, or when stark contrast exists between the pelage of the target species and the background. However, during most surveys a substantial portion of the target species will not be seen during aerial searches; sightability is known to be less than 10% for elk in heavily forested habitats, 50% for bighorn sheep on winter ranges, and as low as 50% for pronghorn (Samuel et al. 1987, Pojar et al. 1995). Gasaway et al. (1986) suggested that moose could not be accurately surveyed in dense forest cover due to low sightability; this observation is reflected in Alberta’s Moose Survey Program, where WMUs consisting of a high proportion of closed canopy conifer forest are not currently surveyed. Therefore, unless sightability corrections are used, survey leaders should only implement aerial ungulate surveys in geographic locations and at times of year when sightability is highest. While in many cases the true sighting probability will be unknown, conducting surveys during the best available weather conditions will ensure that population estimates are as accurate as possible. Nonetheless, surveys which do not incorporate sightability measures will result in a minimum population estimate, and must be utilized for management purposes with this in mind.
In cases where stratified random block surveys are used, survey leaders should strive to develop precise population estimates. Whenever possible, the final population estimates should be within 20% of the mean with 90% confidence intervals. Achieving this goal requires robust stratification procedures, and in many cases may also require sampling more SUs than the minimum of 15. Lynch (1997) provides a more detailed description of methods to determine the best strata from which to select additional SUs for surveying.

**Sex, Age and Antler Classification Standards**

Currently, age, sex and antler classifications are applied inconsistently while completing aerial ungulate surveys. As a result, the data collected are subsequently entered into the FWMIS data base and can be difficult to analyze due to inherent inconsistencies. For example, there are currently 17 different antler classifications used for recording and entering information on antler size. In an effort to maintain consistent data standards applied during aerial ungulate surveys, it is proposed that standard classifications be applied for recording age, sex and antler size. By applying consistent standards, it will become more efficient to enter data and also allow for meaningful comparisons across administrative areas. The following proposed classifications and descriptions were adopted from:


For each species, there is a maximum of three sex classifications; female, male and unknown (Table 2). For each species there are a maximum of four age classes; young of year (YOY), reproductively immature (Juvenile <1yr old), reproductively mature (Adult) and unknown (Table 3). Antler classification is based on three different classes (Class I – III), with each species having varying criteria and bighorn sheep horns are classified based on the estimate length of curl (Table 4).

When survey objectives include estimates of age and sex ratios, surveys must be conducted to ensure that adequate sample sizes of ungulates are classified in order to allow statistically rigorous estimates of herd sex and age structure. Czaplewski et al. (1983) provide examples of how to estimate minimum sample sizes of ungulates needed
to determine age and sex ratios with a desired level of precision when individuals are sighted independently:

\[ n = \frac{Nz^2 pq}{e^2 (N - 1) + z^2 pq} \]

where \( n \) is the sample size needed to estimate the desired population parameter (e.g. buck:doe ratio), \( p \) is an estimate of the proportion of the sample comprising the first sex or age class of interest (e.g. bucks), \( q \) is an estimate of the proportion of the sample comprising the second sex or age class of interest (e.g. does), \( N \) is the estimated population size (bucks plus does), \( z \) is the 2-tailed value from the normal distribution, and \( e \) is the allowable error (in terms of a proportion of \( p \)). Upon calculating the necessary sample size to achieve the desired precision, survey leaders can estimate the effort required to acquire these data using information from past surveys. For example, the number of animals seen/km of transect or per hour of flight time spent searching sampling units should allow an approximate estimate of necessary flight time if animal densities have not changed substantially.
Table 2. Recommended *sex classification* criteria for use in Alberta aerial ungulate surveys for white-tailed deer, mule deer, elk, moose, bighorn sheep and mountain goats. Sex and age terminology to be consistently applied and used for inclusion of data into FWMIS database.

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>White-tailed Deer</td>
<td>Unknown</td>
<td>• Smaller body size and visibly shorter nose, lacks antlers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine sex based on body size</td>
</tr>
<tr>
<td>Mule Deer</td>
<td>Female</td>
<td>• Medium size and no antlers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• May be accompanied by fawns</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>• Larger body size, antlers present as a yearling</td>
</tr>
<tr>
<td>Elk</td>
<td>Unknown</td>
<td>• Smaller body size without antlers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine sex based on body size</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>• Medium size and no antlers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• May be accompanied by calves</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>• Larger body size, antlers present as a yearling</td>
</tr>
<tr>
<td>Moose</td>
<td>Unknown</td>
<td>• Smaller body size without antlers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine sex based on body size</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>• Medium size, no antlers and short bell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Distinguished by white vulva patch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• May be accompanied with a calf</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>• Larger body size, antlers present as a yearling</td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>Unknown</td>
<td>• Small with small horns, typically YOY (lamb)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>• Larger than lambs in horn and body size, but not as large as adult females or male juveniles (Juvenile), or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &lt;1/2 curl horns, often difficult to distinguish from juvenile males</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>• Horn size greater and bases slightly wider and more divergent than ewes</td>
</tr>
</tbody>
</table>
| Mountain Goat | Unknown | • Small body size, short horns, usually with female (kid)  
| | | • Larger than kid, but smaller than adult with a shorter muzzle (Juvenile) |
| | Female (Nanny 2+ yrs) | • Shaggy coat in July  
| | | • Horns have a fairly sharp kink at tip  
| | | • Horns thinner and more wide-spread than males, v-shaped from the front |
| | Male (Billy 2+ yrs) | • Smooth coat in July  
| | | • Horns thicker and closer together than in female  
| | | • Head and neck massive compared to female |
Table 3. Recommended *age classification* criteria for use in Alberta aerial ungulate surveys for white-tailed deer, mule deer, elk and moose. Age terminology to be consistently applied and used for inclusion of data into FWMIS database.

<table>
<thead>
<tr>
<th>Species</th>
<th>Age</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>White-tailed Deer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juvenile (&lt;1yr)</td>
<td></td>
<td>• Smaller body size and visibly shorter nose, lacks antlers</td>
</tr>
<tr>
<td>Adult (female)</td>
<td>• Medium size and no antlers, may be accompanied by fawns</td>
<td></td>
</tr>
<tr>
<td>Adult (male)</td>
<td>• Larger body size, antlers present as a yearling</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine age based on body size</td>
<td></td>
</tr>
<tr>
<td><strong>Mule Deer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juvenile (&lt;1yr)</td>
<td>• Smaller body size without antlers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• May accompany an adult female</td>
<td></td>
</tr>
<tr>
<td>Adult (female)</td>
<td>• Medium size and no antlers, may be accompanied by calves</td>
<td></td>
</tr>
<tr>
<td>Adult (male)</td>
<td>• Larger body size, antlers present as a yearling</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine sex based on body size</td>
<td></td>
</tr>
<tr>
<td><strong>Elk</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juvenile (&lt;1yr)</td>
<td>• Smaller body size without antlers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• May accompany an adult female</td>
<td></td>
</tr>
<tr>
<td>Adult (female)</td>
<td>• Medium size, no antlers and short bell</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Distinguished by white vulva patch, may be accompanied with a calf</td>
<td></td>
</tr>
<tr>
<td>Adult (male)</td>
<td>• Larger body size, antlers present as a yearling</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine age based on body size</td>
<td></td>
</tr>
<tr>
<td><strong>Moose</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juvenile (&lt;1yr)</td>
<td>• Smaller body size without antlers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• May accompany an adult female</td>
<td></td>
</tr>
<tr>
<td>Adult (female)</td>
<td>• Medium size, no antlers and short bell</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Distinguished by white vulva patch, may be accompanied with a calf</td>
<td></td>
</tr>
<tr>
<td>Adult (male)</td>
<td>• Larger body size, antlers present as a yearling</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>• Lacks antlers, observation occurs following antler drop, unable to determine age based on body size</td>
<td></td>
</tr>
<tr>
<td><strong>Bighorn Sheep</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YOY (lamb)</td>
<td>• Small body size, short horns, usually with female (lamb)</td>
<td></td>
</tr>
<tr>
<td>Juvenile</td>
<td>• Larger than lambs in horn and body size but not as large as adult females</td>
<td></td>
</tr>
<tr>
<td>Adult female(eve)</td>
<td>&lt;1/2 curl horns, often difficult to distinguish from male yearlings</td>
<td></td>
</tr>
<tr>
<td>Adult male (ram)</td>
<td>• Horns larger than females or yearling rams</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>• Unable to determine age based on size and/or horn growth</td>
<td></td>
</tr>
<tr>
<td>YOY (kid)</td>
<td>• Small body size, short horns, usually with female</td>
<td></td>
</tr>
<tr>
<td>Juvenile</td>
<td>• Larger than kid, but smaller than adult with a shorter muzzle, horns shorter than ears in early-mid summer.</td>
<td></td>
</tr>
<tr>
<td>Mountain Goat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td><strong>Adult (Nanny 2+yrs)</strong></td>
<td>• usually in groups with females, kids and other juveniles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shaggy coat in July, horns have a fairly sharp kink at tip</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Horns thinner and more wide-spread than males, v-shaped from the front</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Head and shoulders less massive than males</td>
<td></td>
</tr>
<tr>
<td><strong>Adult (Billy 2 + yrs)</strong></td>
<td>• Smooth coat in July</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Horns thicker and closer together than in female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Head and neck massive compared to female</td>
<td></td>
</tr>
<tr>
<td><strong>Unknown</strong></td>
<td>• Unable to determine age based on size and/or horn growth</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pronghorn Antelope</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>YOY (kid)</strong></td>
<td>• Small body size, usually with female</td>
</tr>
<tr>
<td><strong>Adult (female)</strong></td>
<td>• Small horns, absence of black patch on face</td>
</tr>
<tr>
<td><strong>Adult (male)</strong></td>
<td>• Large horns, black patch on face</td>
</tr>
<tr>
<td><strong>Unknown</strong></td>
<td>• Unable to determine age based on size, markings, or horn growth</td>
</tr>
</tbody>
</table>
Table 4. Recommended *antler classification* and description for white-tailed deer, mule deer, moose and elk and horn classification and description for bighorn sheep. Antler classifications be consistently applied and used for inclusion of data into FWMIS database.

<table>
<thead>
<tr>
<th>Species</th>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>White-tailed Deer</td>
<td>Small</td>
<td>• Spike or 2-points on one or both antlers</td>
</tr>
<tr>
<td>and Mule Deer</td>
<td>Medium</td>
<td>• Small to medium size antlers with 3 or more points/antler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Antlers inside ears</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>• Large antlers with 4 or &gt;4 points/antler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Antlers outside of ears</td>
</tr>
<tr>
<td>Moose</td>
<td>Small</td>
<td>• Antler pole type, usually a spike or fork, if palmated, does not extend beyond ear tip</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>• Antlers palmated, with spread &lt; ½ of body length</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>• Antlers palmated, with spread &gt; ½ of body length</td>
</tr>
<tr>
<td>Elk</td>
<td>Small</td>
<td>• Spike antlers or with light 1 to 2 point antlers</td>
</tr>
<tr>
<td></td>
<td>Medium (or branch)</td>
<td>• Small antlers with 3 – 5 points per antler</td>
</tr>
<tr>
<td></td>
<td>Large (or trophy)</td>
<td>• Large antlers with 6 or 7 points/antler, massive</td>
</tr>
<tr>
<td>Bighorn Sheep</td>
<td>¼ curl</td>
<td>• Horns up to ¼ curl</td>
</tr>
<tr>
<td></td>
<td>½ curl</td>
<td>• Horns between ¼ and ½ curl</td>
</tr>
<tr>
<td></td>
<td>¾ curl</td>
<td>• Horns between ½ and 4/5 curl</td>
</tr>
<tr>
<td></td>
<td>4/5 curl</td>
<td>• Horns between 4/5 and full curl</td>
</tr>
<tr>
<td></td>
<td>Full Curl</td>
<td>• Horns that have attained full curl growth</td>
</tr>
<tr>
<td></td>
<td>Unclassified</td>
<td>• Unable to accurately determine size of horns</td>
</tr>
</tbody>
</table>
SPECIES SPECIFIC GUIDELINES

Pronghorn Antelope

Survey Methods

Pre-established, 1-mile wide fixed linear transects within each Antelope Management Area (AMA) are surveyed each year. While this survey approach allows calculations of density as well as herd classification (sex/age ratios), population estimates should be utilized with caution because sightability and/or pronghorn distribution may vary markedly between years.

Every transect line within survey blocks receive aerial coverage by accurately flying the aircraft (Bell 206 Helicopter) along each line at an altitude of 60-90m above ground, with ground speed of approximately 120 km/h. Altitude and airspeed are ultimately governed by the terrain being traversed and the prevailing wind and other weather conditions.

The survey crew consists of four survey personnel including the pilot, lead observer/navigator, and two primary, rear-seat observers. Each primary observer is responsible for continuous visual coverage of a 0.8 km (0.5 mi.) scan strip on their side of the aircraft. The lead observer/navigator (seated to the left of the pilot) is responsible for maintaining an accurate course, recording all pertinent information on data forms and maps, judging observations as whether ‘on’ or ‘off’ transect (using GPS location data), aiding with herd classification and assisting with observing duties as time permits.

Survey Timing

Pronghorn inventories will begin ~July 15 of each year. Surveys must occur at precisely the same time each year to allow comparisons in kid: doe ratios across years. There will be two flights per day, with morning flights departing at approximately 0600h to 0800h depending on the weather forecast for the day and whether or ambient temperatures are expected to be cool or above 30°C. Later departures are allowed if the day is expected to be cooler, as these flights would still terminate by 1100h prior to the warmer part of the day. Early morning flights (0600h) are not necessarily preferred because long “shadows” and flying into the sun (visibility) becomes an issue when the sun is closer to the horizon. Evening flights would depart at or after 1600h (but not after 1730h) each
day to ensure that antelope are not subject to heat stress caused by pursuit aircraft. Departures later than 1730h often have the same “shadowing” and sun/brightness issues towards the end of the flight. Each flight should not exceed 3 hours in duration.

Classification
All pronghorn should be classified as either being adult males, adult females, or kids (Table 3). At the time surveys are conducted (mid-July), kids can be easily distinguished from adults based on body size and snout length. Adult males have a clear black marking on the side of the face, and have horns that are substantially larger than those on females.

All ‘on’ transect observations are accurately counted, classified (bucks, does, and kids) and separately recorded (with a separate waypoint) on each transect line. In many instances this information can be recorded from small herds without deviating from the transect line. Such information for large herds requires a cooperative effort by the lead observer (kid count) and one rear observer (buck and total count) and may require multiple checks until confidence in the count can be established. The doe segment is calculated by subtracting the two known components from the total count. In many cases the other rear observer can participate in this exercise thus providing an accuracy check.

When it is apparent that sample sizes on monitor blocks are <100 does in a particular AMA, “off” transect observations should be similarly counted and classified to increase the sample size and hence accuracy of projected sex/age ratios. All such information is separately notated and excluded from density projections and used to calculate sex/age ratios.
Mule and White-tailed Deer

Survey Methods
Deer surveys occur only in the southern, central and agricultural-dominated WMUs in the boreal portions of the province, where deer densities and recreational demand are highest and relatively sparse forest cover permits good sightability. Deer surveys are conducted as stratified random block surveys (3 minutes latitude X 5 minutes longitude in southern and central portions of the province and 5 minutes latitude X 5 minutes longitude in the farmland WMUs in northwestern Alberta) in order to allow the calculation of accurate population estimates and confidence intervals. Stratification of survey units occurs through pre-stratification flights and expert knowledge of deer distribution with relation to habitat. More recently, researchers at the University of Alberta have begun development of resource selection functions for both white-tailed and mule deer in parkland habitats; these models may prove extremely useful for cost-effectively stratifying deer surveys in southern and central Alberta.

The intensive portion of the survey should be conducted with a Bell 206 helicopter, with survey lines spaced approximately 400m apart and the aircraft traveling at 80kph and 100m above ground level. Survey crews should consist of a pilot, lead observer/navigator, and 2 rear-seat primary observers. Each primary observer is responsible for continuous visual coverage of a 200m scan strip on their side of the aircraft. The lead observer/navigator (seated to the left of the pilot) is responsible for ensuring an accurate course, recording all pertinent information on data forms and maps, aiding with herd classification and assisting with observing duties as time permits.

Survey Timing
Deer surveys should be conducted during winter (December-March) when sightability is highest due to leaf-fall and snow cover. In prairie habitats, the rarity of good snow conditions may necessitate that surveys are conducted when bare-ground is present; under these circumstances the speed of survey aircraft and distance between transect lines may need to be reduced in order to ensure adequate sightability. Where accurate sex ratios or buck size classifications are needed, surveys should be conducted in December to ensure that bucks have not initiated antler drop.

Classification
During the intensive portion of stratified random block surveys for deer, all deer should be classified by species and as either juvenile, adult male or adult female (Tables 2-3). Mule and white-tailed deer can be readily distinguished based on coloration of the tail, with white-tailed deer having a characteristic white underside to the tail, which is often raised while running, and mule deer having a narrow, white tail with a black tip and white rump. Juvenile deer have a smaller body size and shorter nose than adults, and antlers are absent on both sexes. Adult females are of medium size with no antlers present, and are often accompanied by juveniles. Adult male are typically larger than females with antlers present. Antler-drop for deer begins mid-winter, so accurate sex ratios can be determined only when surveys are conducted early during the survey season (i.e., in December).
Mountain Goats

Survey Methods

In Alberta, Mountain Goats are surveyed using a trend count procedure. Surveys occur within discrete Goat Population Areas (GPAs), which are WMUs or portions of WMUs that encompass one or more goat herds and individuals within a defined geographical area usually separated by a valley (Figures 3-6). Each GPA is located within a Goat Management Area (GMA; Figure 7). It is important to use standardized methods to inventory GPAs so that data can be compared between years to determine trends, to compare to results collected in other GPA’s and to monitor status relative to management goals and objectives.

Annual surveys can provide an index of kid mortality if the yearling to adult ratio in one year is compared to the previous year’s kid to adult ratio. However, such ratios should be interpreted with caution, as the distribution of individual herds in the complex and herd composition (e.g., the number of males and sub-adults) may change from year to year so that changes in ratios may not represent kid mortality (Smith 1984). Additionally, kid and yearling classification in very large maternity groups such as Caw Ridge (>65) is problematic (Gonzalez-Voyer et al. 2001). If kid mortality is to be tracked through ratios, it is necessary to maintain an annual survey schedule on a representative number of herds. Likewise, long-term trends require periodic surveys in subsequent years. In order to provide a control group to hunted herds, a sample of un-hunted herds should also be surveyed at the same interval.

During surveys, a total census of each survey complex (i.e., Goat Population Area) is attempted with a helicopter and surveys are done as consistently as possible (i.e., same pilot, navigator and observers). Each drainage basin is surveyed in a counter-clockwise direction to enable the navigator and observer on the left side of the helicopter to directly view the uphill side of the valley. The flight line is located approximately equidistant between timberline and ridge top. When the search area is too wide to be effectively searched in one pass, additional passes are made as required. Airspeed ranges from 100 kph to 130 kph, depending on wind and terrain.

The inventory crew consists of a pilot, navigator (observer) and two primary observers. The primary observers occupy the rear seats in the helicopter and are responsible for continuous visual coverage of each search area (i.e., middle of the slope to ridge top and
middle of the slope to timberline below). The right rear observer records all pertinent information on the field data sheets and enters locations of goats on a GPS. GPS entry can also be performed by the navigator if required. The navigator occupies the left front seat and ensures all areas are covered.

**Survey Timing**

Mountain goats are inventoried from a helicopter in July approximately 1 month after the last kids are born and nursery groups congregate on open alpine meadows making them more observable. At this time, groups are relatively large, yearlings can be distinguished by experienced observers, and the molt is still a helpful indicator of age and sex classes.

Whenever possible, flights are scheduled in early morning (0600-0900 hours) and late evening (1800-2200 hours) when mountain goats are most active, temperatures are cooler and wind is minimal. Maximum activity usually occurs on bright, clear days at least five hours after cloudy periods of rain and inclement weather (Fox 1977), but surveying on bright, cloudless days presents problems with severe glare and contrast. Additionally, surveying during very hot (27-30°C) days should be avoided as goats will be very difficult to find. Although time constraints seldom permit waiting for perfect conditions, poor conditions substantially reduce data quality and should be avoided if possible (Smith 1984). Surveys are not flown during low cloud and/or sustained rainfall conditions.

**Classification**

When possible, mountain goats should be classified by experienced observers as adult, yearling (smaller than adults and horns less than ear length) or kid. In order to minimize the chance of mountain goats falling during classification from the air, each group is approached from below if possible and made to run uphill. When group sizes are between 5 and 15, goats can be classified from the helicopter by the navigator and left rear observer with one counting yearlings and the total and the other counting kids and the total. When yearlings are not distinguishable, the goats would be classified as “kids” and “goats older than kids”. When encountering large groups (>15) or goats in hazardous terrain, the helicopter should land, usually less than 1 km away, so observers can classify the goats from the ground, using a 20-45 power spotting scope, (Cook 1985). This technique improves the quality of data and reduces harassment of the goats.
Photographs are useful in classifying large groups and verifying numbers after the survey. For groups with <5 goats, the navigator (or any observer) can complete both the classification and total count.

Aerial survey data for mountain goats in Alberta typically focuses on providing trend information for hunting management and/or to track herd status relative to other management needs. Variability within years is often significant and should be used with caution (Gonzalez-Voyer et al. 2001). Although sightability averages 60-70% in Alberta (Gonzalez-Voyer et al. 2001) and other jurisdictions (Cichowski et al. 1994; Poole 2007; Rice et al. 2008) the minimum total count provides a conservative basis by which to allocate hunting effort.
Figure 3. Goat Population Areas (GPAs) in Goat Management Area A.
Figure 4. Goat Population Areas (GPAs) in Goat Management Area B.
Figure 5. Goat Population Areas (GPAs) in Goat Management Area C.
Figure 6. Goat Population Areas (GPAs) in Goat Management Area D.
Figure 7. Goat Management Areas (GMAs) in Alberta.
Bighorn Sheep

Survey Methods

Bighorn sheep winter ranges are surveyed using a trend count survey of known winter ranges during periods of good snow cover and low winds by Bell 206 helicopter. Only those sheep management areas that meet the following criteria are surveyed:

i. the population is subject to trophy and/or non-trophy hunting

ii. the population can be surveyed on fairly well-defined winter ranges and is not widely dispersed, and

iii. the winter population is larger than 20 animals.

For those sheep management areas meeting the above criteria, enough winter ranges should be surveyed to account for approximately 80 percent of the total sheep population, based on historic population information. Winter ranges will be surveyed on a 2-year rotational basis, where possible, so that a portion of provincial ranges in the north and south are surveyed each year. Because of the clumped distribution of bighorn sheep, aerial surveys (or ground surveys which are intended to estimate population or distribution characteristics) must include entire winter ranges. Any population that experiences a die-off should be surveyed several times during the year of the die-off, to accurately determine the timing and extent of mortality; thereafter, surveys should be done annually until winter lamb:ewe ratios reach acceptable levels (>25-30 lambs:100 adult ewes).

All surveys should be conducted with a Bell 206B helicopter, with a pilot and lead observer/navigator in the front and two rear-seat observers. Each mapped sheep winter ranges should be thoroughly searched within each sheep management area, with the same winter ranges surveyed across years within each area. Each winter range is flown slightly above tree line and at higher elevations to cover mountain ridges and cliffs. Multiple passes may be required to obtain adequate coverage. Observers should use sightings of fresh tracks and direct observations of sheep to guide searching. Additional sheep that are outside traditional winter range boundaries should not be included in the total counts of conventional winter ranges, but should be considered for addition into future winter range surveys if they are consistently observed in the same area. Winter ranges should be reassessed through a combination of historical survey information, additional observations and local knowledge to determine if additional or new survey units are required.
Groups of sheep should be approached from below and pushed uphill to aid in classification and reduce chances of injury to fleeing sheep. A total herd count should be obtained first followed by a classified count. For larger herds (>20), the helicopter should stay back and allow the observers to count and classify while the animals are standing still. Try to avoid having animals start to run or different herds running and intermixing. Once sheep are running or get into the trees they are extremely difficult to move out to where they are visible. Image stabilizing binoculars are recommended for classifying sheep during aerial surveys. It is often beneficial to have the lead observer calling out individual sheep classifications and have one of the other observers keep a running tally until the entire herd has been counted and classified. The location of each sheep herd should be accurately recorded with a GPS.

_survey timing_
Surveys for bighorn sheep should ideally occur between January to March following snowfall that is sufficient to cover all ground vegetation and rocks. Sheep will be more congregated on winter ranges under these conditions. Bright sunny days are favorable for spotting sheep and/or their tracks. Windy conditions should be avoided both to ensure the safety of mountain flying and to maximize the likelihood that sheep will be above treeline. Windy conditions also increase the difficulty to classify and count bighorn sheep. Additionally, when possible avoid survey during patchy snow conditions or when old snow is on the ground as visibility becomes increasingly more difficult.

_classification_
Bighorn sheep should be classified as young of the year (YOY – lambs), juvenile (yearlings), adult female (ewes), or adult male (rams). Additionally, adult males should be classified as ¼ curl, ½ curl, ¾ curl, 4/5 curl (trophy and greater (trophy)). Lambs are easily distinguished from other categories based on small body size and the presence of very short horns. Juveniles are clearly larger than lambs and they have smaller horn and body size than adult males. Juvenile males have horns with heavier bases and are stockier than adult females, but they can extremely difficult to reliably distinguish from adult females, and are often included in the adult female classification. Adult males are readily distinguished from other age and sex classes based on horn and body size. If
unable to accurately classify individual sheep, effort should be made as a minimum to categorize as either unclassified rams or unclassified ewes/lambs.
Bison

Survey Methods
Bison are surveyed using winter range trend surveys, using a 2-part approach. During good snow conditions, fixed-wing aircraft are used to search bison range for herds and fresh tracks; these locations are then thoroughly searched with a helicopter. The helicopter crew conducts herd counts and classification.

Survey Timing
Locating bison concentrations requires that animals are congregated, and depends on excellent snow conditions which improve visibility and aid in the detection of tracks. Therefore, surveys are typically conducted from late February to mid March.

Classification
Bison are typically classified as calves, adult bulls, and unknown. Bison calves are easily distinguished based on their small body size and adult bulls are much larger and more massive in both horn and body size than other sex and age classes. Juvenile males and females cannot be readily distinguished from adult females except by extremely experienced observers, and even then this level of classification may require extensive circling of herds. Caution is advised as bison are not tolerant of low-flying aircraft and will disperse, potentially causing further classification problems. When possible digital herd pictures should be taken at an elevation where the herd is not dispersing and correlated with the herd GPS location and count. These pictures can be enhanced to show and verify calf counts at a latter time.
Moose

Survey Methods
Moose are surveyed using a stratified random block approach throughout the parkland, foothills, and boreal regions of Alberta. Survey units (SUs) should be 3 minutes latitude X 5 minutes longitude in parkland and foothills WMUs (i.e., typically high-density WMUs) and 5 minutes latitude X 5 minutes longitude in northern boreal WMUs (i.e., typically low density WMUs). Stratification of SUs occurs through pre-stratification flights and expert knowledge of moose distribution with relation to habitat and local features that influence moose distribution within a WMU. Ongoing research in west-central Alberta may ultimately allow stratification via resource selection models; however these models have not yet been developed and may not be applicable to parkland or boreal habitats.

The intensive portion of the survey should be conducted with a Bell 206 helicopter, with survey lines spaced approximately 400m apart and the aircraft traveling at 80kph and approximately 100m above ground. Height above ground will vary with terrain and forest density; areas with taller trees should be searched from a higher altitude to allow observation down into the vegetation. Survey crews should consist of a pilot, lead observer, and 2 rear-seat observers. Each rear-seat observer is responsible for continuous visual coverage of a 200m scan strip on their side of the aircraft. The lead observer/navigator (seated to the left of the pilot) is responsible for ensuring that the pilot maintains an accurate course, recording all pertinent information on data forms and maps, aiding with classification and assisting with observing duties as time permits.

Survey Timing
Moose surveys are conducted during winter and when snow conditions allow good sightability. Surveys should be conducted after hunting seasons, but before moose begin dispersing from distinct wintering areas that result in clear stratification of SUs. In most cases, surveys should occur from December-February, although March surveys may be acceptable during some years when moose remain in wintering areas during this period.

Classification
Moose are classified as juveniles (< 1 year old, calf), adult females, and adult males (Tables 2 and 3). Juveniles have a noticeably smaller body size than adults, short nose/muzzle, in effect no bell and typically travel with an adult female. Adult females have no antlers, a short bell, and a distinct white vulva patch that is readily observed from the rear (Figure 8). Adult males lack the white vulva patch, and during early winter surveys often have antlers present. The small size and localized position of the vulva patch on moose requires that all antlerless moose are viewed from the rear in order to confirm sex. Moose will typically turn and run from a rotary-wing aircraft when the aircraft hovers near the moose, allowing a rear view of the animal. Circling a moose will often cause it to continually change position to face the aircraft, preventing the rear view that is necessary for sexing. Therefore, pilots must be capable and willing to hover safely when at nearly full weight capacity when conducting moose surveys. In addition, moose that remain bedded may need to be approached closely to force them to stand and allow sex classification. When a group of moose is encountered, the pilot may need to separate each individual from the group and pursue them independently in order to confirm sex.

When antlers are observed, they should be classified as small when antlers are a spike, fork, or do not extend beyond the ear tip, as medium when antlers are palmated but have a spread of <1/2 body length, and as large when palmated and with a spread >1/2 body length and/or with major points to the front (Table 4).

In addition to sex and age classifications, moose should be rated for intensity of tick infestation (Figure 9).
Figure 8. Photos of the white vulva patch on female moose (A) and the lack of a distinct white patch on male moose (B). From Mitchell (1970).
Figure 9. Tick infestation classification categories for moose during aerial surveys in Alberta.
Caribou

Survey Methods

Beginning in the late 1980’s, ASRD has conducted late winter composition surveys for selected woodland caribou populations in the province (Figure 10). The number of surveyed populations has gradually increased over time. These data are entered into the provincial caribou data base, and in combination with adult female mortality data collected quarterly, are used to calculate an annual population trend (lambda) value for each population. Population trend measurements contribute fundamental data to the assessment of woodland caribou recovery and conservation actions, within context provided by the Alberta Woodland Caribou Recovery Strategy (Alberta Woodland Caribou Recovery Team, 2005) and by Alberta’s obligations within the Federal Species at Risk legislation.

Because the goal of caribou surveys in Alberta is to complement mortality data, which requires continual monitoring of radiocollared adult females, and due to the expense associated with searching for caribou for classification, caribou composition surveys focus on groups associated with caribou that have been radiocollared as part of the provincial monitoring program. Immediately prior to the composition survey for each herd, radiocollared female caribou are located with fixed-wing aircraft, which are much more cost effective for conducting radiotelemetry over large areas than helicopters.

Following initial locations, a survey crew, consisting of a pilot, lead observer, and 2 rear-seat observers uses the GPS coordinate and telemetry to re-locate the collared individual(s), and classifies all caribou in associated herds. Additional caribou that are sighted by the survey crew but not associated with radiocollared caribou are also surveyed to determine herd composition whenever possible.

Survey Timing

Caribou recruitment surveys are conducted in February and March of each year, when the presence of snow improves sightability and the majority of first-year mortality in calves has already occurred.

Classification

Each caribou is classified into adult female, adult male, female calf, and male calf based on body size, antler development, and the presence of a black vulva patch on females.
Females of all ages show a black vulva patch, while males of all ages generally show only white in that area, with sometimes a slight faecal staining. Small antlered adults that do not have a calf at heel should be classified as unclassified adults, if a rear view is not achieved.
Figure 10. Locations of caribou ranges surveyed for herd composition in Alberta.
Elk

Survey Methods
Elk are surveyed using a trend count on identified winter ranges throughout the prairies, foothills, and mountains of Alberta. In some areas of the prairie-parkland regions, elk populations are enumerated as a secondary objective during stratified random block surveys that are conducted for moose and deer. For trend surveys, previously delineated winter ranges are searched for elk during good snow conditions that allow adequate sightability. Survey crews consist of a pilot, lead observer/navigator (left front seat) and 2 rear-seat observers. The flight path for surveys should follow a predetermined trajectory designed to cover traditional winter elk ranges. Parallel transects may be flown in some ranges where elk are widely dispersed in order to cover the area more thoroughly. Search efforts should be primarily concentrated in areas with visible elk tracks in the snow.

Large elk herds present challenges in obtaining accurate counts. When a larger group of elk are observed, a total count should be estimated by visually breaking the group into smaller sub groups by terrain, landscape changes, or natural divisions within the herd. These smaller groups can be tallied as the pilot circles the group at moderately high altitude to avoid spooking the elk. One of the crew members can also take digital photographs of the larger groups as well. The photographs can be magnified back in the office to obtain a more accurate count.

Survey Timing
Elk surveys should be conducted from January-March, when snow is likely to be deepest and elk are on winter ranges. Optimal survey conditions include fresh snow and low winds. When possible, surveys should be conducted at similar timing across years in order to ensure comparability of survey results.

Classification
Elk should be classified into juveniles, adult males, and adult females whenever possible. Juveniles are readily distinguished from adult elk based on body size and the shape of the head (Figure 11), and typically accompany an adult female. Adult females do not have antlers and are smaller than adult males. Adult males typically have antlers present until late winter, and except for yearlings, are clearly larger bodied than adult females (Table 2 and 3).
Figure 11. Classification of calf (top), yearling (middle), and adult cow (bottom) elk as evidenced by body size and shape of the head.
LITERATURE CITED


