USE OF AERIAL SURVEYS FOR ESTIMATING AND MONITORING MOOSE POPULATIONS - A REVIEW

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ABSTRACT: The use of aerial surveys for estimating and monitoring North American moose populations is briefly reviewed. These include the use of transects, selected plots or quadrats, aircraft type, survey periodicity, accuracy and precision, use of a sightability correction factor, optimum survey criteria, current survey standards, and the role of sex-age composition surveys, including sex and age identification criteria.

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Counting moose from aircraft when they are on winter range is the most common method of estimating moose numbers in North America (Timmermann 1974, Gasaway *et al.* 1986, Gasaway and DuBois 1987). Aerial surveys are used in obtaining measures of relative population size and distribution over large areas, determining population trends, estimating annual recruitment, and building public confidence in management and research programs. Their shortcomings include; high costs, potential lack of suitable aircraft, need for experienced pilots and/or crew, high sightability error estimates, and variation in snow and weather conditions during and between surveys.

Several methods including transect censusing and intensively searching sample units or plots were developed in the 1950's and 1960's (Timmermann 1974, Gasaway *et al.*1986). Two approaches are generally used; searching an entire area, or sampling a portion of it. Sampling is more commonly used because estimates can be made for large management areas that are pre-stratified for sampling based on expected densities of moose. Commonly the stratification is made from either observations of moose or their tracks or habitat considerations. Sampling units randomly selected from each stratum may consist of either transects or plots.

Transects

In 1945, Aldous and Krefting (1946) made the first recorded estimates of moose numbers based on winter aerial surveys on Isle Royale Michigan. They flew transects covering 30% of the island and estimated 510 moose. The line transect or strip method of censusing moose involves flights along pre-selected parallel routes at a fixed altitude over snow-covered ground. Surveys are often conducted in four-seat aircraft,with crews consisting of a pilot, a navigator/recorder, and two rear-seat observers (Banfield *et al.* 1955). Observations are made in a strip from 0.2 to 0.5 km (0.13-0.3 mi) wide on either side of the flight line. These lines are generally laid out on topographic maps or aerial photos with the desired degree of coverage dictating the distance between transects. Surveys are flown at an altitude of about 250 meters (800 ft) at an air speed of 140 km per hour (90 mi/hr). The angle of sight is used to determine transect width and together with length are used to calculate total area sampled. Decisions to include or exclude animals sighted outside or near transect boundaries are critical due to their effect on the variance of the estimate.

Several technical and logistic problems are associated with transect surveys. They include: restricted to relatively flat terrain; generally low moose sightability, resulting in a large and variable proportion of missed moose and a large variance; special high resolution maps or photos required; and the bias and precision of incorporating a sightability correction factor for missed moose has not yet been fully evaluated (Gasaway and Dubois 1987). Transect sampling has several advantages compared with plots including: lower cost per square kilometer; less observer fatigue; ability to stratify areas by relative densities and then assign blocks by optimal allocation; and ease of location in areas with few landmarks.

The transect method was discontinued in many jurisdictions because results lacked the necessary accuracy and /or precision needed to provide information useful for management (Timmermann 1974). Today only a few agencies including Idaho, Saskatchewan and Nova Scotia continue to use transects to monitor long-term population trends, recognizing estimated densities can be extremely variable among years. Several jurisdictions including Minnesota, Ontario, Alberta, and Alaska used transects in 1991 to obtain distribution and relative density estimates (stratification) for different areas prior to random quadrate sampling (Peterson, Bisset, Todd and Spraker personal communication 1992) .

Both Thompson (1979) and Dalton (1990) attempted to incorporate visibility bias into the line transect survey by calculating the distribution of distances from the centerline of the survey to animals observed. Dalton (1990) suggested that this 'modified' line transect method should be more accurate than plot search methods because more information is used, including use of observed tracks to find moose. However, the line tansect census relies on four basic assumptions that must be met to minimize bias and maximize accuracy: 1) moose groups on the centerline are not missed; 2) groups are fixed at the initial sighting; 3) distances to observed moose are estimated accurately; and, 4) observations are independent events (the same moose are not tallied on more than one transect). The ability of different observers to satisfy these assumptions varies widely.

In summary, transect surveys appear best suited to estimate moose populations and/or distribution over large areas with low moose densities where a high degree of accuracy and precision are not required.

Selected Plots or Quadrats

Plots refer to a general category of sample units that are uniform squares, rectangles, or irregular in shape and area (Gasaway and Dubois 1987). Aerial surveys of randomly selected plots were first introduced in Ontario in 1958 (Cumming 1958). Population estimates were based on the number of moose actually observed plus those estimated to have been present but not seen on each 65 km^2 (25mi^2) plot (Lumsden 1959).

The method usually consists of dividing the area to be censused into strata on the basis of relative population densities previously determined by a variety of methods including vegetation, soil type, animal counts, and track counts. Each stratum is divided into sampling units of a predetermined size. A random selection of sample plots in each stratum is made, then each plot is intensively searched. Some survey estimates are based on a random selection of sample units from an unstratified population. The perimeter of each plot is first flown to identify precise boundaries. Searching involves a circling pattern over fresh tracks or moose sighted, along parallel predrawn flight lines. Overlap of adjacent flight paths increases in homogeneous habitats where few topographic features are available for navigation. Moose density estimates are summed for all sample plots for each stratum and a population estimate is extrapolated for the entire survey or management area.

Pimlott (1961: 248) suggested that even with intensive search procedures "only about 75% of the moose can actually be seen" , however such sampling tends to yield consistantly higher estimates than those obtained by using transects. For example, Lynch

(1971) reported that in Alberta only 67% of the moose observed on plot surveys were spotted during straight line counts. Likewise Evans *et al.* (1966) in Alaska estimated only one-fourth as many moose were seen in a surveyed area using transects compared with intensively searched plots. Gasaway *et al.* (1986) concluded the percentage of moose sighted is a function of search intensity and that in interior Alaska a search effort of 1.5 to 2.0 min/km^2 (4 - 5 min/mi^2) was required to see most moose during early winter.

Aircraft Type and Survey Periodicity

Both the type of aircraft used and observer experience contribute to survey precision. The characteristics of aircraft best suited include manoeuvrability and slow flight capabilities. An air speed of 104 to 144 km per hour (65-90 mi/hr) at an altitude range of 60 to 240 meters (200-800 ft) is considered ideal. Helicopters are considered best. They have the advantage of low speed, low cruising altitude, excellent overall visibility, ease of manoeuvrability, and superior downward viewing. However, they often have a limited range and are much more expensive to operate than fixed-wing aircraft. The two-seat Supercub (Piper PA-18) is regarded the best fixed-wing aircraft (Evans *et al.* 1966). Larger four seat aircraft including the Cessna 180 and the DeHavilland Beaver, although often used, are faster and less manoeuvrable (Bergerud and Manuel 1969).

Moose distribution in many jurisdictions covers large land masses. Surveys in Quebec, for example are carried out on approximately 600,000 km^2 (231,000 mi^2), divided into 20 management zones. Fifteen of these are surveyed every 5 years.

Effective management of moose is enhanced when populations are assessed on a regular basis. Aerial surveys initiated in the early 1990's are carried out annually in 11 of 23 North American jurisdictions managing moose, to assess population trends and sex/age composition. The balance (12) conduct periodic surveys (i.e. Alberta every 1-3 years, Washington every 5 years, Maine as needed).

Survey timing varies, with the majority of agencies conducting surveys in December - January, whereas Alaska, Yukon, and Northwest Territories prefer November. Utah, North Dakota, Ontario, Quebec, New Brunswick and Nova Scotia may continue surveys into Febuary or March. Helicopters are used exclusively by half the jurisdictions, four employ only fixed-wing aircraft, and six use both. Helicopters are best suited to help determine the age and sex composition of the population by allowing close observation of individuals or groups. Their flight characteristics enhance close visibility of primary and secondary sex and age indicators and the ability to land nearly anywhere to check sign or refuel gives them an advantage over most fixed-wing aircraft.

It is believed but untested that helicopter searches yield counts more accurate than those obtained with fixed-wing aircraft but their greater operating costs often preclude use (Jordan and Wolfe 1980, Rivest *et al.* 1990).

Accuracy and Precision

The major problem in counting moose in forested habitat is accounting for missed animals. Aerial surveys if properly conducted can provide a high degree of precision (repeatability and narrow confidence limits about the mean estimate) and incorporate sightability correction factors that improve accuracy.

The accuracy and precision of aerial plot counts using controlled experiments and known moose numbers were examined by Le Resche and Rausch (1974) in Alaska. Under ideal conditions, 49 observers flew 74 replicate counts over four fenced 2.6 km^2 (1 mi^2) fenced moose enclosures. Experienced and inexperienced observers flying 15 minutes over each enclosure saw 68 and 43% of the moose present, respectively. They believed additional factors affecting observability were past and recent observer experience, number of observers, weather conditions, habitat and terrain, time of day, and relative moose densities. High moose densities particularly in mixed or heavy cover reduced survey accuracy as tracks were not helpful to locate animals. Le Resche and Rausch (1974) concluded that census conditions must be ideal and as nearly constant from year to year to obtain counts that provide valid estimates of the relative size of the herd and population trends among surveys.

Gasaway *et al.* (1986) recommends a minimum acceptable search time of 1.5 min/km^2 (4 min/mi^2) in interior Alaska, and sometimes 2.3 to 3.0 min/km^2 (6 - 8 min/mi^2) in heavier cover or where densities exceed 1.5 moose/km^2 (4/ mi^2). Adjustments in search effort will be required as sightability varies among areas of North America.

Plot size can affect total counts. Smaller plots 2.6km^2(1.0 mi^2) cause less observer fatigue and their boundaries are often easier to locate. Larger plots, may reduce the bias of edge effect due to reduction of edge to area sampled. The variance about the mean number of moose per plot tends to decrease with larger plot size, whereas smaller plot size tends to increase the variance (Evans *et al.* 1966, Bergerud and Manuel 1969).

Moose distribution is generally patchy rather than homogenous. Stratification of range into relative high, medium and low density strata can help reduce variance and increase survey precision. Ideally plots should not include so many animals that accuracy in heavy cover is lost, or too few to produce many zero plots (Bergerud and Manuel 1969). Samples are seldom large enough to reduce the confidence interval to less than about 30% according to Addison (1970). Gasaway *et al.*(1986) recommend striving for precision equal to or greater than a 90 % confidence interval with a width less than ± 25 % of the population estimate.

Sightability Correction Factor

Aerial surveys nearly always underestimate the number of animals present (Caughley and Goddard 1972). Sightability estimators are therefore needed to develop estimates of actual animal numbers. Research, particularly in Alaska, Ontario, Quebec, and Newfoundland has advanced estimation procedures since the late 1970's (Cook and Jacobson 1978, Thompson 1979, Gasaway *et al.* 1986, Crete *et al.* 1986, Oosenbrug and Ferguson 1992). A sightability correction factor can be generated and multiplied by the number of moose actually sighted, times the area surveyed, to derive a more accurate population estimate. Survey precision is calculated by combining the variance of total moose observed plus the variance of the sightability correction factor. When evaluating data precision it is important to remember that changes in population estimates of about 20% or more are required before real population changes can be detected (Gasaway and Dubois 1987).

Three methods commonly used to estimate the sightability correction factor are: 1) resurveying a portion of a sample unit either at a higher search intensity (ie. at least twice the original time) and assuming that this intensity locates all of the moose present (Gasaway *et al.* 1986), or by incorporating a more efficient aircraft (helicopter rather than fixed-wing), 2) counting the number of fresh tracks where moose are not sighted and multiplying by the mean aggregate size of moose observed (Bergerud and Manuel 1969) or, 3) using marked moose in a Peterson-index calculation (Oosenbrug and Ferguson 1992). In the latter case, moose can be radio-collared and/or marked with paint or colour- collared. Ratios of radio-collared or marked moose present and observed to total moose observed in the sampling area are calculated to determine the sightability correction factor (Table 1). Desired survey accuracy and available funds will dictate which method is used as all three require additional effort and cost.

Table 1. A sample of sightability correction factor (SCF) estimates obtained from a variety of North American moose surveys.

Agency	Mean Density per km²	Effort min per km²	SCF estimate	Reference
Ontario	-	2.0-3.9	1.04-1.06[4]	Novak and Gardner (1975)
Yukon	0.21	4.0	1.03-1.11	Larson per. comm. (1993)
Alberta	-	-	1.14	Mytton and Keith (1981)
Michigan (Isle Royale)	1.3-2.5	-	1.19	Jordan and Wolfe (1980)
Maine	0.66	7.6	1.23[4]	Maine Department of Inland Fisheries and Wildlife (1990)
Ontario	<0.39	1.2	1.27[4]	Bisset and Rempel (1991)
Quebec	0.05-0.18	-	1.37	Crete *et al.* (1986)
Michigan (Isle Royale	2.0-2.6	14	1.35	Peterson and Page (1993)
Montana	-	-	1.47-2.07[5]	Montana Department of Fish, Wildlife and Parks. (1992)
Alaska	2.7-19.1	5.8	1.48[2]-2.33[1]	LeResche and Rausch (1974)
Newfoundland	0.5-2.8	2.6	1.59-2.49[5]	Oosenbrug and Ferguson (1992)
Newfoundland	0.6	-	1.67[6]	Bergerud and Manual (1969)
Colorado	-	-	1.74[5]	Kufield (1992)
Ontario	0.18	-	1.75-2.60[3]	Thompson (1979)

[1] inexperienced observers
[2] experienced observers
[3] transect survey
[4] higher intensity search - ie 1.5 min per km²
[5] mark - recapture census
[6] mean track aggregate method in intermediate tree cover

Higher sightability correction factors are usually associated with denser cover and higher moose densities (Gasaway *et al.* 1986, Peterson and Page 1993).

Optimum Criteria

The following criteria have been identified as important to obtaining an accurate population estimate: 1) counts should be made within a short period (2 to 5 days) after a fresh snowfall; 2) weather should be clear or lightly overcast; 3) wind speeds should be under 16 km per hour (10mi/hr); 4) counting should be restricted to short periods of 2-3 hours, ideally to coincide with the period of greatest moose activity, just after sunrise; 5) only currently experienced observers and pilots should be used; 6) sufficient time should be allotted to fully search each plot (i.e. a minimum of 1.7min./km² or 4.5 min./mi²); 7) accuracy can be increased by using more than one observer and including animals tallied by the pilot; and, 8) maximum counts in most forested habitats with adequate snow cover (30 cm or 12 in.) can usually be obtained in December and January before moose shift into heavier cover (Vozeh and Cumming 1960, DesMeules 1964, Bergerud and Manuel 1969, Gasaway *et al.* 1986).

Snow depth and condition are important factors that can influence the ability to count moose and the variability in successive counts of the same area. Sufficient snow is needed to cover dark ground objects (stumps and rocks) and allow observation of fresh tracks. Snow measurements should therefore be recorded during each survey so that density estimates between surveys can be better evaluated.

Accurate trends in population estimates and composition can only be achieved through rigorous adherence to a standard set of criteria and conditions under which surveys should be conducted (Gasaway *et al.* 1978).

Current Standard

The current recognized standard for conducting aerial moose census was developed in Alaska in a step by step manual described by Gasaway *et al.* (1986). They believe five criteria for estimating population size based on aerial inventories are essential: 1) be unbiased, ie. on average avoid over or under estimations of actual population size; 2) provide an adequate level of precision (as indicated by the width of confidence intervals) based on realistic measures of sampling errors; 3) be suitable for flat, hilly, or mountainous terrain; 4) not require special maps or photos for sampling; and, 5) be affordable.

Methods of estimating population size are based on a stratified random sampling design modified from Siniff and Skoog (1964), and Evans *et al.* (1966). Bias is minimized by using flight patterns providing high sightability of moose and by estimating sightability correction factors for moose not seen. Estimates of precision combine sampling variance of estimated observable moose and sampling variance of the estimated sightability correction factor to determine a more accurate overall density estimate. Use of irregular shaped sample units and varying search patterns adapt the technique to various terrain features. Use of natural terrain features on topographic maps avoid the need for special maps or photos. Rate of population change (increase or decrease) over time can be determined from a comparison of population estimates separated by one or more years.

Five steps in the census procedure include: 1) define the population of interest and select a survey area; 2) delineate all possible sample units on a topographic map; 3) stratify the area by conducting a preliminary aerial survey to determine relative (high, medium, and low) moose densities; 4) randomly select a number of sample units and recount some units using a more intensive search effort to estimate percentage of moose missed; and, 5) calculate an estimate of population size and confidence limits. This method of censusing moose has been widely used throughout North America in recent years to estimate moose abundance (Bailey 1978, Gasaway *et al.* 1983, Crete 1987, Ballard *et al.* 1991, Bisset and Remple 1991, Gasaway *et al.* 1992). The technique is costly, especially for large areas, as it relies on aircraft and may yield only crude estimates of abundance in areas of dense cover.

Sex-Age Composition

The composition of a population or its social structure is important in properly assessing a moose population (Bubenik *et al.* 1975). Managers should not rely solely on numerical censuses but consider periodic composition surveys. Sex and age composition estimates are influenced by moose behavior since they often segregate by sex and age, making some classes more difficult to observe than others (Peek *et al.* 1974, Thompson and Vukelich 1981). The numbers of moose in specific sex-age classes in a population can be estimated from observations made during routine population surveys or special composition surveys. Moose are commonly classified into numbers of bulls, cows and calves, so that composition between years and between areas can be compared. Ratios are expressed as bulls per 100 cows, calves per 100 cows and calves (single or twin) as a percentage of total moose classified. Gasaway *et al.* (1986) cautioned that data from population estimation surveys in Alaska produce higher and more representative calf:cow ratios than surveys conducted to gather composition data alone. Presumably the former provides a more representative sample within intensively searched habitat types, while the latter can be biased by including only those animals easily sighted in open cover.

Survey intervals to detect changes in composition may also be as frequent as every 2 years or once in 5 years, depending on the dynamics of the specific population.

Sex and Age Identification Criteria

Correctly classifying observed moose is critical in assessing population structure and determining the dynamics of the system. Moose sex and age indicators can be divided into either primary or secondary characteristics after Oswald (1982) and Crichton (1987). Observers should strive to combine two or more *primary* and *secondary criteria* when conducting surveys. Primary criteria include antler or pedicle scars, vulva patch, size and behavior, and bell size and shape, while secondary criteria include aggregation make-up, face coloration, body conformation and color, head position while moving, and position of legs when arising from beds. A description of the pimary and secondary criteria follows.

Antlers and pedical scars. The presence of antlers always indicates a male which is ≥1 year of age. Antlered bulls can be placed into one of three classes as follows:

Class 1- Teenager (1.5 - 2.5 yrs.). These animals are composed of either spike, fork, or multiple fork (non-palmated) antlers (Fig.1).

Class 2- Sub Prime (3.5 - 4.5 yrs.) composed of palmated antlers (Fig.2). Characteristics of

Fig. 2. Antler profile of class 2- (sub prime 3.5 - 4.5 yr. old) moose.

palmated antlered bulls include:

- main palm (not including points) generally does not extend beyond the ear tips
- brow tines are usually single rather than forked
- width of individual palms narrower than head width
- points relatively short and few in number
- antler spread is generally less than 100cm (40in.)

Class 3 - Prime (≥5.5 yrs.) individuals composed of large palmate antlers (Fig.3). Characteristics of large palmated prime bulls include:

- main palm excluding points extends beyond ear tips
- brow tine usually forked or palmated
- width of individual palm as wide as head
- points long and numerous, rounded off on occasion at palm tip
- antler spread generally greater than 100-114 cm (40-45 in.)

Unantlered Bulls - When antlers are dropped

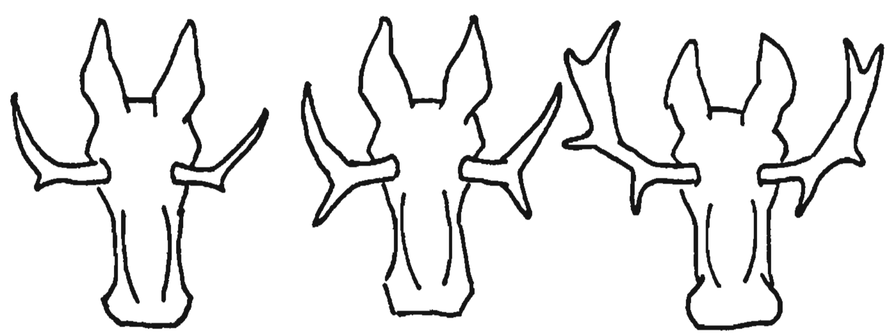

Fig. 1. Antler profile of class 1- (teenage 1.5 - 2.5 yr. old) non palmated moose.

Fig. 3. Antler profile of class 3- (prime $\geq$5.5 yr. old) moose.

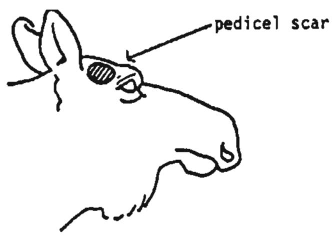

Fig. 4. Head profile of an antlerless male moose showing location of the pedical scar.

(usually begining late November) an open wound 4 to 8cm (1.5 - 3 in.) in diameter is left at the point of attachment to the skull and flush with the skin (pedical scar- Fig.4). This scar is dfficult to see and should not be used unless closely observed (i.e. from a helicopter).

Vulva patch. The vulva patch (Mitchell 1970) is an area of light coloured hair (approximately 10 x 20 cm or 4 x 8 in. in adults) located below the tail around the genital area of female moose (Fig.5). This light area is in sharp contrast to the adjacent dark hair and may vary from white to a light tan colour. Observers should always attempt to determine the presence or absence of a vulva patch on adult antlerless moose. After antlers, this patch is the best indicator of sex. This technique should be confined to adults ($\geq$1.5 yrs.) as variation in calves may occur due to the occurance of pale coloured hair in the ano-vular region of some male calves (Roussell 1975).

Size and behavior. Size variation between individual moose is useful in identifying cow/calf groups or aggregations. Body size is the most useful feature in distinguishing calves from adults. Calves also exibit relatively small ears compared to head size and have a shorter stouter 'face' than those of older moose which display a longer and more bulbous nose (Fig.6). On occasion, large calves can be mistaken for yearlings,thus close attention must be given to head features. Antler stubs when silhouetted against snow can be used to confirm calf sex (Eason 1986).

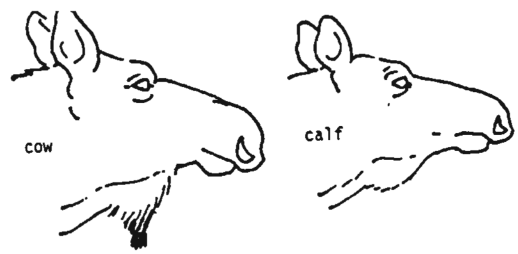

Fig. 6. Relative size and shape of an adult cow and calf moose head.

Although cow-calf groups are almost always identified by body size differences, several behavioral traits are helpful. Cows and calves are always found very close together, often bedded side by side and seldom sepa-

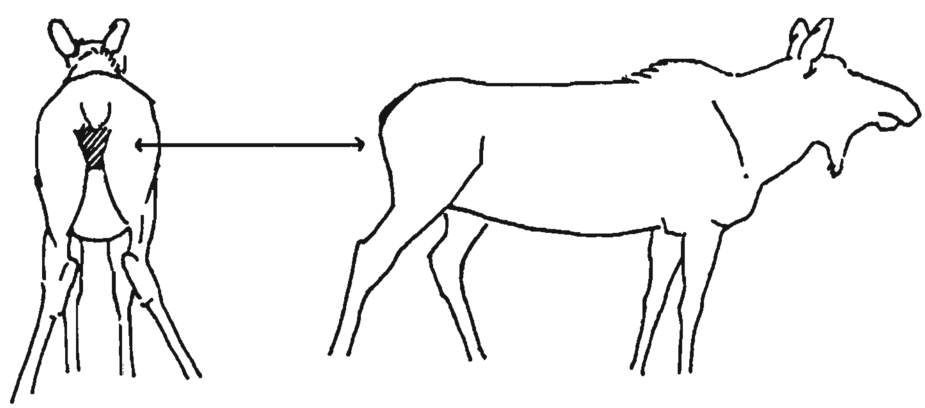

Fig. 5. Location of the vulva patch on a female moose.

rated by more than 30 to 40 metres. Often they are separated from other sex-age classes of moose. When disturbed, the calf or calves, almost without exception,will after the initial disruption, follow directly behind the cow and close at heel.

Bell size and shape. The shape and size of the bell, which consists of hair-covered skin hanging under the throat, helps to identify the sex and relative age of adult moose (Timmermann *et al.* 1985). Mature or prime bulls display a significantly larger and longer bell than cows (Fig 7). The longest bells, narrow and rope-like in appearance are usually found on juvenile bulls 2.5 to 3.5 years of age. Older prime bulls often display a large, prominent wide sack-shaped bell with a narrow "rope" section of varying length attached.

Aggregation make-up. Bulls frequently form bachelor groups after the rut, with two to 12 or more animals (Timmermann 1992). Adult cows likewise may form small groups of two to six. Both sexes often choose open mixed-wood habitat with good quantities of browse in early winter. Cow-calf groups generally select sites away from other groups and in conifer dominated stands (Peek *et al.* 1974, Thomson and Vukelich 1981). Cow-yearling groups on occasion re-form after the rut,while solitary bulls and cows are often prime-age individuals.

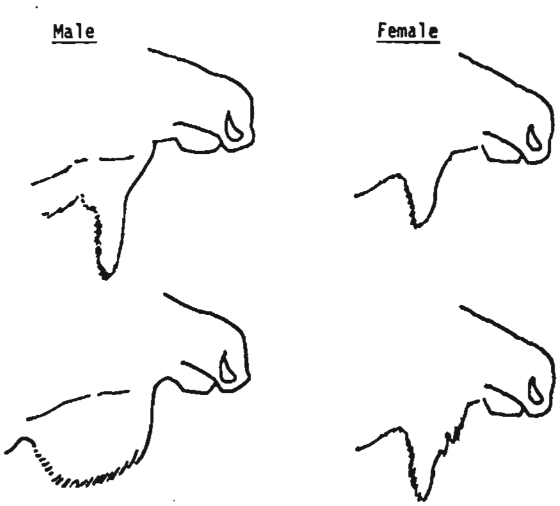

Fig. 7. Typical bell profiles of young (teenage) and mature (prime) male and female moose.

Facial coloration. Although coloration patterns vary by area, generally coloration of the nose-bridge or face can be a reliable secondary sex identifier among adults after antler drop (Fig.8). A light brown colored nose-bridge, with little or no contrast between nose and forehead, is indicative of a cow over one year old. Conversely, the nose-bridge of mature bulls is generally dark brown or black contrasting with the lighter forehead area. The overall face coloration of cows tends to be lighter with age, whereas those of bulls darken. The degree of facial darkness in bulls is believed related to seasonal production of testosterone (Bubenik *et al.* 1977). The face of calves show little colour differences between sexes.

Body conformation and color. Generally this indicator is useful only for recognizing mature or prime bulls and should not be used alone. They tend to have a stocky 'wedge-shaped' outline when observed broadside, exhibit heavy shoulder development and are often dark brown or black over their torso (Crichton 1987). Cows, in particular, and younger bulls are generally slimmer and show more brown body coloration.

Head position while moving. As a general rule, bulls frequently move with their foreheads more perpendicular to the ground, while cows move with their foreheads more parallel to the ground (Fig.9)(Crichton 1987).

Position of legs when rising. When aroused from beds by searching aircraft, adult bulls frequently stop and place their legs forward in a urination-like position (Fig.10). Cows do not display this type of posture (Crichton 1987).

All moose observed can be placed into one of the following sex and age classes: (antlered bulls, unantlered bulls, adult cows, unknown adults, and calves- either single or twins. Antlered bulls can be further grouped into several social classes based on antler size and shape.

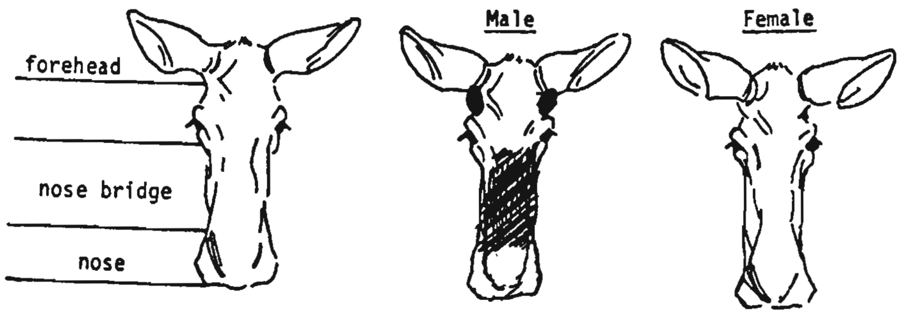

Fig. 8. Face coloration of adult (1.5 yr.) male and female moose.

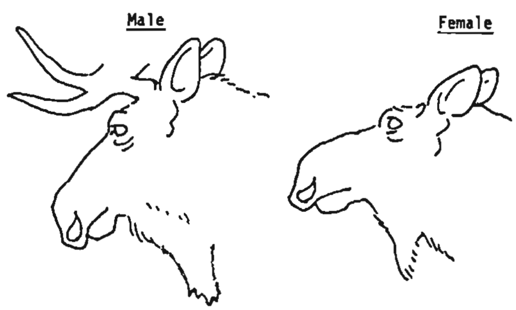

Fig. 9. Typical head stance of moving male and female moose.

SUMMARY

Aerial surveys are the most practicle and widely used method of estimating moose numbers and distribution in North America. Disadvantages include high costs, high sightability error estimates especially in heavy cover and variation in conditions between surveys. The use of transects and quadrat sample units is discussed as is aircraft type and survey periodicity. Good estimates are precise and unbiased and recent advances have improved survey precision by incorporating sightability correction factors for most sources of variation. Optimum criteria and the current recognized standard for estimating moose population parameters from aerial surveys are reviewed. In addition the value of conducting special sex/age composition surveys using a variety of primary and secondary identification criteria is discussed.

Fig. 10. Crouched-urination posture of male moose after being aroused from a bed.

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